ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) OF THE BUJAGALI HYDROPOWER PROJECT (BHPP), UGANDA FISHERIES COMPONENT

The First Quarter Survey of the Aquatic System and Fisheries of the Upper Victoria Nile, 6^{th} – 13^{th} April 2006

A Report Prepared For R.J. Burnside International Limited

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Executive Summary

In pursuit of developing a 250MW hydropower plant on the Upper Victoria Nile in Uganda, the EIA recommends collection of baseline data prior, during and post plant construction. In 2000, AES Nilepower commissioned an Aquatic and Fisheries Survey of the Upper Victoria Nile to identify potential impacts upstream and downstream of the project site at Dumbbell Island, which was done by NAFIRRI (FIRRI at the time). The present survey assignment was conducted during April corresponding to the Second quarter of AES Nilepower Survey of 2000 and covered similar transects between Kalange (Upstream of the proposed site) and Namasagali (furthest site downstream of the proposed site). The four sampling sites were chosen considering the ease of sampling, transport logistics and ecological diversity. The studies were carried out under standard and acceptable methodologies for the assessment of aquatic system and included socio-economics, bilharzias and other disease vectors and sanitation which were not covered during AESNP Survey of 2000.

The first quarter report on Environmental, Social/Sanitation/Vectors and Impact Assessment (ESIA) undertaken during April 2006 by the National Fisheries Resources Research Institute (NAFIRRI) contracted by Burnside includes introductory chapter, field procedure, sampling protocal and data analysis and eleven chapters on:

- Water quality characteristics
- Algal biomass and species composition
- Aquatic macrophytes
- Micro-invertebrate fauna
- Macro-invertebrate surveys
- Fish species composition and relative abundance
- Biology and ecology of the fishes
- Fishery catch survey
- Bilharzias, other disease vectors and status of sanitation
- Socio-economics
- Discussion and conclusion

The present survey information is compared with the AES Nilepower second quarter survey both having been conducted in the rainy month of April.

Findings were:

Water quality characteristics

Conductivity patterns (2006) reduced progressively downstream while in 2000 it was relatively stable. NO_3-N were higher in 2000 compared to 2006 survey while TP was higher in 2006 compared to 2000. Chl-a showed a progressive reduction in 2006 while oil and grease showed an increase at all transects. Less suspended solids were noted in 2006 at all transects compared to 2000. Along all the transects H_2S and C_2H_4 never changed much at all the transects and these were not analysed in the April 2000 survey.

Algal biomass and species composition

Blue-green algae dominated the algal community in all transects with similar algal distribution and abundance patterns in both surveys.

Aquatic macrophytes

41 macrophyte species (2006) compared to 46 species were encounted. In 2006 however, transect 4 had four times more species in 2006 than in 2000 due to colonization as a result of lower water levels of a wider transect. Water hyacinth (*Eichhornia crasipes*) and Hippo grass (*Vossia cuspidata*) remained the same during the two compared quarters.

Micro-invertebrates

Similar longitudinal patterns, abundance and species richness were observed for the two surveys with more species being upstream and transects 1-3 dominated by copepoda.

Macro-invertebrates

Highest total benthic density dominated by mollusks was transect 1at Kalange (April 2000) and at transect 3 (Kirindi) in 2006. Ephemenoptera (mayflies) and Tricoptera (Caddis fry) were less abundant (2000), probably due to reduced water levels and sampling in restricted habitats.

Fish species composition and relative abundance

The same keystone species (*Mormyrus kannume, Barbus altianalis, Lates niloticus* were encounted both surveys. In April 2000, 21 species compared to 18 in April 2006 were noted; *M. kannume* dominated in 2000 while Haplochromines were more dominant in 2006 both in biomass and number.

Biology and ecology of the fishes

There were no major differences in the diet and ecology of keystone species in April 2006 compared to April 2000. Fecundity in almost all species (in 2000 and 2006) was not easy to determine as specimens with ripe eggs were not easily obtainable.

Fishery survey

No major changes in fishing effort (crafts) were recorded. The types in use (57% increase in Ssese type, 39% decrease in dugout crafts) and increase in fishers (89 in

April 2000 to 128 in April 2006) this leading to increase in fish traders from 12 in 2000 to 47 in 2006. Target species remained the same and *Rastrineobola argentea* had the highest catch rate (300 kg boat^{-1}). Haplochromines and *R. argentea* were important in April 2006 commercial fishery. The main fishing gears remained the same so were the hook sizes in use. Monthly fish yield from the four transects increased from about 8,000 kg (April 2000) to 17,000 kg (April 2006) with a value of 4m and 12m Ug. Shs respectively.

Bilharzias, other disease vectors and status of sanitation

The baseline information on vector snails (spread of bilharzia) and non-vector snails showed that non-vector snails were more abundant than vector snails except at Namasagali (Transect 4). Of the two-vector snail genera encounted, *Biomphalaria* sp were more abundant at Kalange (Transect 1) and Kirindi (Transect 3) showing a high risk of *Schistosoma monsoni* than *Schistosoma haematobium* at these transects. Samples collected from a range of water users showed that 50% of the population were infested with *Schistosomiasis.* These were mainly the fishers, swimmers/bathing where there was the highest risk.

Feacal coliform contamination due to *Salmonella* and *Shigellosis* contamination was higher at the shallow human and water contact points than in deeper waters. All sites were far above acceptable limit of 5 celonies per 100 mls of water. Crabs collected during the survey did not have Simulim larvae that cause river blindness.

Socio-economic findings

The major economic activity at the four sampled sites is agriculture supplemented by subsistence fishing. The fish species harvested include Nile perch (*Lates niloticus*), Nile tilapia (*oreochromis niloticus)*, *Barbus* - Semutundu, M*ormyrus* - Kasulu and *Barbus* sp – Kisinja. Beach Management Units are not fully established.

The fishers on average earn US$ 5.5-16 per week but only 9.8% of the fishers had the culture of saving.

89% of the fishers own fishing assets while the rest rent these inputs that include multifilament gill nets, hooks, oars and boats.

However, the fishers experience fewer fishing areas leading to reduced fish catch and income from fishing.

1. Background to the Baseline Aquatic Monitoring and Fisheries Survey of the Upper Victoria Nile

1.1. Introduction

Burnside Bujagali Hydropower Project is to develop a 250 MW hydroelectric power plant on the River Nile. The project site is located at Dumbbell Island near the source of the Victoria Nile in Uganda and is about 2.5 km downstream from Bujagali falls (Fig. 2.1a). The ESIA is a follow-up of AESNP EIA conducted in 2000 but has been overtaken by events since then. The ESIA has been conducted in conformity with the methodologies used during AESNP survey.

An Environmental Impact Assessment (EIA) report together with the Environmental Action Plan and Monitoring Plan was submitted by AESNP to Government of Uganda. The EIA recommended collection of baseline water quality and aquatic ecology data, which included the following:

- Hydrology
- Water quality
- Indicators of productivity of lower trophic levels (invertebrates) including critical or keystone species
- Fish and fish population
- Human uses of the aquatic ecosystem particularly as a source of food

The Burnside Bujagali Hydropower Project in addition to the above has included fisheries Socio economics and disease vectors/sanitation. EASNP commissioned FIRRI in 2000 to undertake the required data collection for the pre-construction phase and as a follow up once more, the Burnside Bujagali Hydropower Project has commissioned NAFIRRI.

NAFIRRI is one of the institutes of NARO charged with the responsibility to promote, undertake and coordinate applied research in fisheries, fish production systems and the environment, aquaculture, fisheries, socio-economics while conserving the natural resource base in Uganda. The Institute is also responsible for packaging and transferring research results to users of research information.

The applied research assists among other issues to ensure,

- Increased supply of adequate and balanced food,
- Maintenance and sustainability of fish production, water quality and a healthy aquatic environment,
- Sustained supply of raw material for local industries,
- Stimulation of production for export diversification,
- improvement in rural incomes and quality of life,
- Conservation of the natural resource base for sustainable development,

- Determine macrophyte composition and distribution
- To carry out invertebrate surveys
- To study the biology of fishes and food webs
- To carry out fish stock and fish catch surveys
- To carry out fisheries socio-economic surveys
- To carry out sanitation/vector studies.

The purpose of this present study therefore is to provide and update the AES Nile Power EIA baseline information on the ecology of the river ecosystem prior to the construction of the dam. The study is intended to provide a basis for evaluating the impact of the project on the river environment, the biological resources associated with it and fisheries socio-economics and the vector/sanitation status.

This report presents the findings of the first sampling regime which was conducted between the dates of 6th – 13th April 2006 and compared with the AESNP Environmental Impact Assessment findings of the second quarter carried out during 5th – 14th April 2000.

CHAPTER 2

2.0. General Methodology and Data Collection

2.1. Materials and Methods

The selected section of the Victoria Nile lies between Kalange/Makwanzi (GPS 36N 0516569, UTM 0054358) to Namasagali/Bunyamira (GPS 36N 049400, UTM 0112000). Kalange/Makwanzi was recognized as the main upstream site and three others downstream of the project site were with increasing distance from Dumbbell Island: Buyala, Kibubamutwe, Kirindi/Namasagali/Bunyamira (Fig.2.1a). The sections of the Victoria Nile in which these sites lie is characterized by rapids, rocky outcrops and river bends. However, such sections merge into slow flowing water zones downstream of numerous islands.

The hinterland along the banks of the study area has been transformed by human activity from the originally wooded savannah landscapes to one dominated by smallholdings of a variety of crops. Perennial crops especially coffee and bananas and annual crops such as maize presently cover the banks and islands. In the more northerly downstream sections, the banks still retain a more natural cover of the original vegetation and a wider flood plain.

For purposes of the survey, four sites were selected. Transects at these sites were recognized according to accessible locations on opposite sides of the river (Table 2.1).

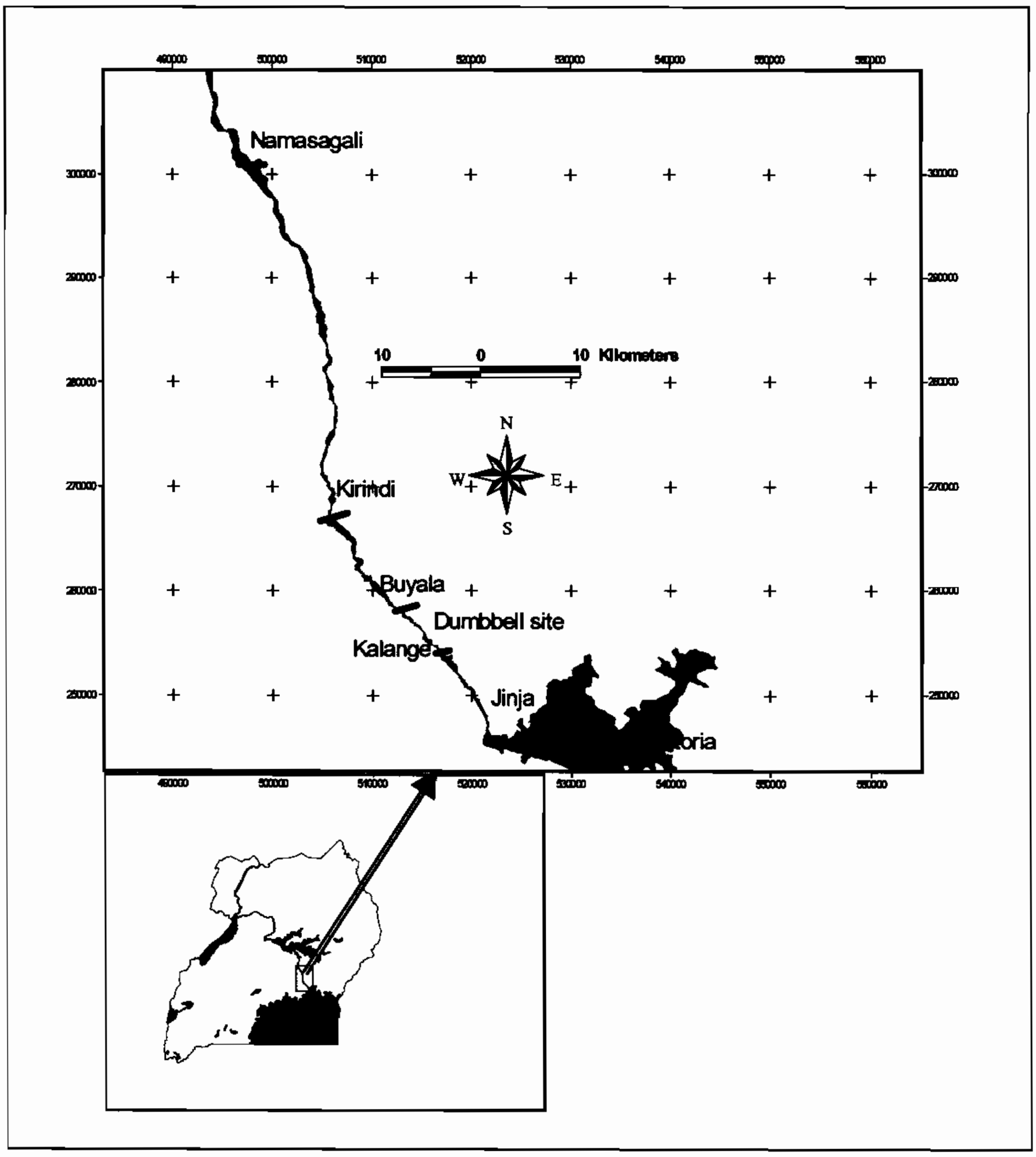


Fig. 2.1a. Location of Project site at Dumbbell Island and the four sampled transects on the Upper Victoria Nile - Uganda

Table 2.1. The distribution of sampled transects and sites along the Victoria Nile

Transect	Location in relation to Dumbbell Island	Sampling base on eastern bank	Sampling base on western bank	Associated villages
1	Upstream GPS 36N 0516569 UTM 0054358	Kalange	Makwanzi	Kikonko Kunjaba Makwanzi Is.
2	Downstream GPS36N 0514575 UTM 0056409	Buyala	Kibubamutwe	Naminya Kisadha Ofwono Zaire Mugalya Kisoga
3	Downstream GPS 36N 0506200 UTM 0075800	Nankandulo	Kirindi	Matumu Kisoga A, B, C Damba
4	Downstream GPS 36N 0494000 UTM 0112000	Karawe - Namasagali	Bunyamira	Kasanga Kibuye Sajjabi

2.2. Identification of Transects along Victoria Nile

The study transects were identified by a team of FIRRI scientists (2000) together with the representatives of AESNP and WS Atkins International Ltd and revisited before the present survey was conducted. The criteria to identify the sampling transects were based on:

- Accessibility on either side of the bank
- Fishing activities in the transect
- Proximity upstream or downstream of the proposed hydro-electric power site at Dumbbell Island
- Transect that covers a wide range of habitats
- Ease to sample aspects of the project objectives
- Transects chosen to be representative of the upper Victoria Nile as a whole

The transects identified (Fig 2.1b) and agreed upon by the two parties were:

Transect 1. Kalange/Makwanzi (36N 0516559, UTM 0054358)

Six km upstream of the proposed hydroelectric power station at Dumbbell. This transect lies downstream of the Bujagali falls. Five islands occur in the transect. The east bank is more gently sloping towards the river and more extensively cultivated than the west bank. Along the river margins *Vossia cuspidata* is the dominant macrophyte occurring in 5 to 15 m wide strips. The tree cover on islands was composed of *Tremor orientalis* and *Ficus* species. The transect was chosen because it had plenty of islands which could shelter more fish and provide more presence of diverse communities.

Transect 2. Buyala/Kibubamutwe (36N 0514575, UTM 0056409)

1km downstream of the proposed hydroelectric power station at Dumbbell Island. This zone is characterized by steep banks on both sides of the river channel. There are rocky reaches and the shoreline for the most part was free of stable vegetation cover. At Buyala/Kibubamutwe, several islands interrupt the flow of the river and create some gentle water flow in restricted zones. The transect was chosen because of its characteristic steep banks on both sides of the river.

Transect 3. Kirindi/Matumu (36N 0506200, UTM 0075800)

24 km downstream of the proposed hydroelectric power station at Dumbbell Island. This site was approached from the more gently sloping west bank at Kirindi. The river channel here is interrupted by a series of islands in an otherwise fast current. At the river margins, the main plant communities were associated with *Vossia cuspidata* and *Phragmites mauritianus*. Beyond the river margins, the land on both sides of the channel was extensively cultivated. The transect sites were selected because they were intensively cultivated near the banks

Transect 4. The furthest downstream transect was located at Namasagali/Bunyamira (36N 0494000, UTM 0112000)

65km downstream of Dumbbell Island. This is the most down-stream site of the survey area and is located at Namasagali/Bunyamira. In comparison to the upstream sites, the river channel here is wider, about 1.5 km and characterized by a more gentle flow. The channel is also associated with a narrow but more defined flood plain at its margins. Both banks are fringed by extensive *Cyperus papyrus* swamp. The river shoreline had frequent patches of *Eichhornia crassipes* and other floating water plants. The transect was chosen because of the gentle wide flowing river.

The detailed locations of the four sampled transects and associated villages are shown in Figure 2.1b.

2.3. Hydrology

Hydrological information is expected to be obtained from DWD and in the form of direct data by Burnside.

2.4. Sampling

Sampling was conducted between the period of 6th – 13th April 2006. The weather for the sampling period was wet.

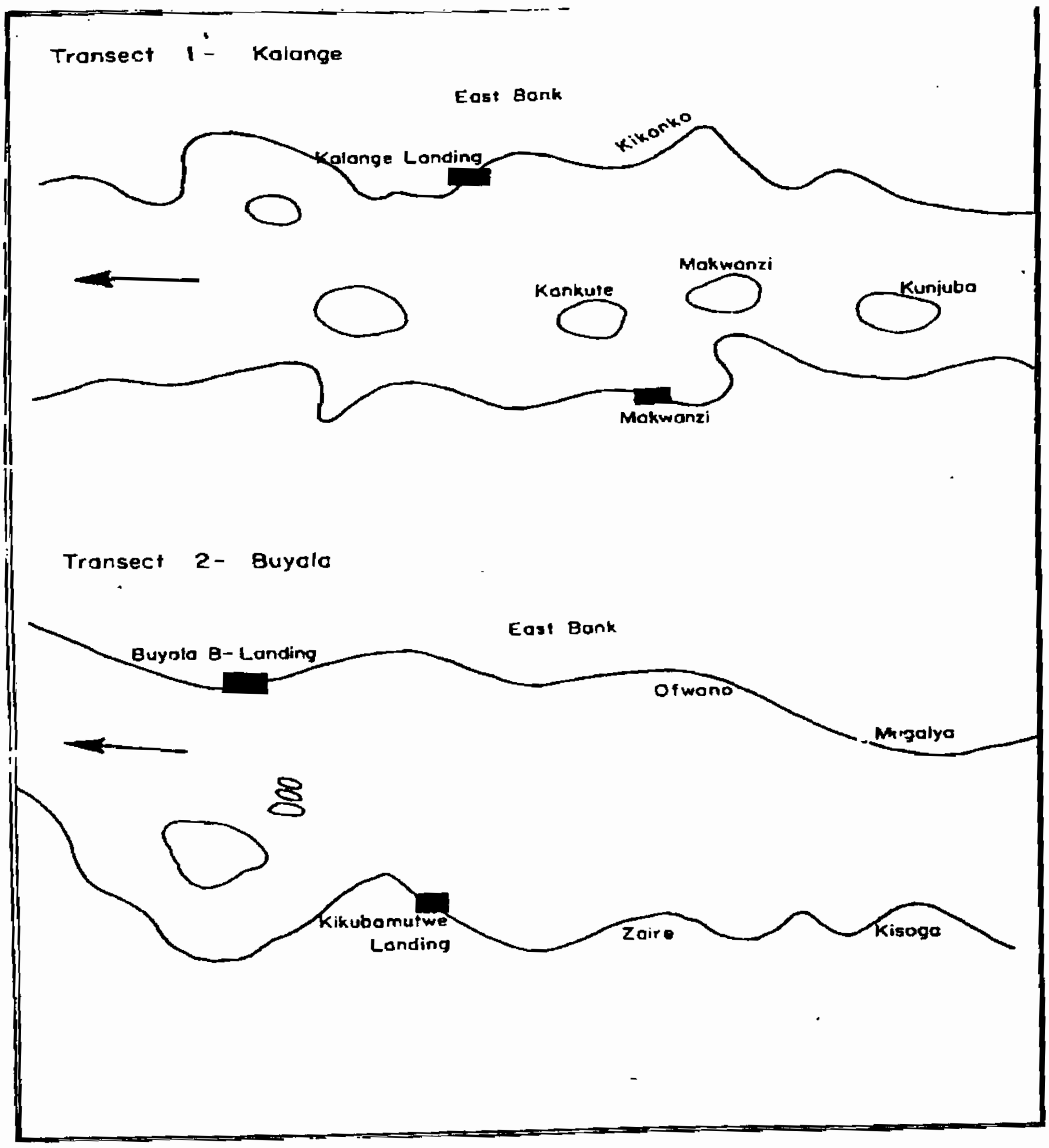
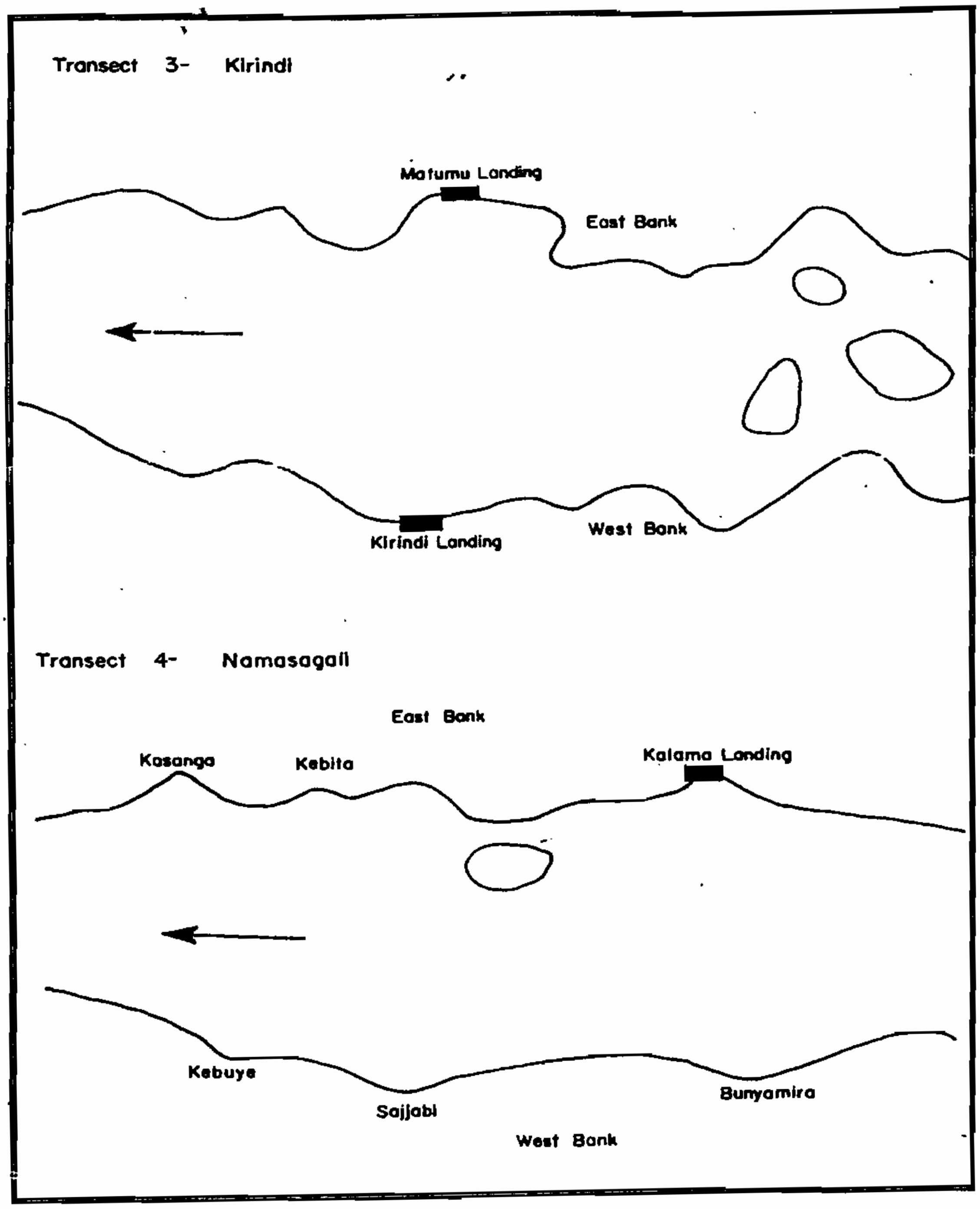


Fig. 2.1b. A description of the sampled transects (Transect 1 = Kalange; Transect 2 = Buyala; Transect 3 – Kirindi; Transect 4 = Namasagali) and associated locations on the Upper Victoria Nile.


Transect 3- Kirindi
Matumu Landing
East Bank
Kirindi Landing
West Bank
Transect 4- Namasagali
East Bank
Kasanga
Kebita
Kalama Landing
Kebuye
Sajjabi
Bunyamira
West Bank

CHAPTER 3

3.0. Water Quality Characteristics

3. 1. Background

A hydroelectric power dam is to be constructed at the Bujagali waterfalls along the Upper Victoria Nile. As part of an Environment Impact Assessment, a survey was conducted to collect information on the status of water quality. Data was collected on a range of physico-chemical parameters namely total suspended solids (TSS), temperature, dissolved oxygen, conductivity, water transparency, pH, various species of nitrogen and phosphorus, silica, methane, hydrogen sulphide, oil and grease, in addition to chlorophyll-a. This data was then compared with that collected at the same transects during the same period i.e. April 2000. This particular survey of April 2006 was carried out during the onset of the first rains in the year.

3.2. Materials and Methods

Four transects sampled along the Upper Victoria Nile were at Kalange, Buyala, Kirindi and Namasagali. Temperature (°C), dissolved oxygen (mg L^{-1}), conductivity (µS cm^{-1}) and pH were measured in situ using Orion portable meters. Water transparency was measured in meters (m) in the shade of the boat using a 25 cm diameter white disc at all sites during sample collection. A 3 L van dorn water sampler was used to draw water samples for analysis of nutrients, oil and grease. Samples for nutrient analysis were immediately kept in a cool box stocked with ice to reduce deterioration of perishable nutrients. Unless otherwise specified, most of the analyses were done following standard methods for the examination of water (Greenberg *et al*, 1992). Water samples for dissolved nutrients were filtered within four hours of collection and analyzed immediately. Water samples for oil and grease were put in glass bottles and those for methane and hydrogen sulphide in plastic bottles. All samples were kept on ice in a cool box and delivered to the laboratory for analysis the same day. The nutrients (i.e. ammonium nitrogen (NH_3-N), nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), total nitrogen (TN), soluble reactive phosphorus (SRP), total dissolved phosphate (TDP), total phosphate (TP) and silica (SRSi)) were determined as described in Stainton *et al.* (1997).

Analyses of water for suspended solids were determined by weight difference. Here, the initial weight of an oven-dried filter paper (Whatman GFC filters) was obtained before using it to filter a known volume of water. After the filtration, the filter papers were then dried for 1 hour at 105°C before reweighing. Water samples for oil and grease were preserved using hydrochloric acid whereas those for methane and hydrogen sulphide were kept at low temperature under ice. These had to be delivered to the laboratory in Kampala the same day in order to meet the critical holding time of the gaseous state.

Analysis was carried out by the National Water and Sewerage Corporation (NWSC) Laboratory using the partio-gravimetric method as described in Greenberg *et.,al.* (1992). Chlorophyll a was determined by the standard spectrophotometric method (Greenberg *et al,* 1992).

3.3 Results

3.3.1. Physical parameters

Physico-chemical and biological parameters are given in Tables 3.1 and 3.2. Electrical conductance of the water in April 2006 ranged between 78.7 and 102.9 μScm^{-1}, with the lowest mean (80 μScm^{-1}) at Buyala and highest (102.5 μScm^{-1}) at Kalange, both of which are upstream transects. Variability in electrical conductivity did not however, differ greatly from previous data of 2000 (Table 3.2). Dissolved oxygen ranged between 4.0 and 7.0 mg L^{-1}, with the lowest mean (4.2 mg L^{-1}) at Kalange and highest mean (6.5 mg L^{-1}) at Kirindi, but with minimal variation. It was noted that dissolved oxygen concentration tended to increase downstream. Comparison of data for April 2006 and that of April 2000 indicated higher mean concentrations of dissolved oxygen during the latter period (Table 3.2). Mean water temperatures varied between 26.4 ^oC at Buyala and 27.0 °C at Kalange and Kirindi during 2006 survey. A similar trend was noted for the 2000 survey, with temperature ranging between 26.3 ^oC at Buyala and 26.6 ^oC at Kirindi. The pH ranged between 6.9 and 7.7 for the 2006 data, with most of the figures centering around circumneutral. The 2000 data however, showed a wider range (5.7 to 8.9). Mean secchi depth during the 2006 survey decreased steadily downstream while the opposite was generally true for the 2000 survey (Table 3.2). During the two surveys, suspended solids were highest at Kirindi and lowest at Namasagali. At Kirindi, mean suspended solids were 2,500 $\mu g\ L^{-1}$ in 2006 and 3,250 $\mu g\ L^{-1}$ in 2000. At Namasagali, the mean suspended solids were 1,500 $\mu g\ L^{-1}$ in 2006 and 818 $\mu g\ L^{-1}$ in 2000 (Table 3.2).

Table 3.1. Comparison in the ranges of physico chemical parameters at the four sampling stations of the Upper Victoria Nile

Variables	2006				2001			
	Kalange	Buyala	Kirindi	Namasagali	Kalange	Buyala	Kirindi	Namasagali
Cond. (μScm^{-1})	102.1 - 102.9	78.7 - 98.2	79.8 - 80.2	81.6 - 88.1	96.0 - 101.0	95.0 - 100.0	98.0 - 101.0	96.0 - 102.0
DO (mg/L)	4.0 - 4.4	6.2 - 6.4	6.0 - 7.0	6.0 - 6.2	4.1 - 10.2	6.7 - 8.3	6.1 - 10.7	5.4 - 8.3
Temp. (C)	26.4 - 27.0	26.3 - 26.5	26.7 - 26.8	26.5	25.3 - 26.8	26.0 - 26.7	26.4 - 26.7	25.3 - 26.6
pH	6.9 - 7.1	7.2 - 7.7	6.93 - 7.6	6.86 - 7.29	5.68 - 7.72	6.75 - 8.28	5.64 - 8.86	6.58 - 7.87
SD (m)	1.8 - 2.0	1.6 - 1.9		1.0 - 1.6	0.95 - 2.16	1.52 - 1.97	1.23 - 1.96	1.22 - 2.9
SS ($\mu g\ L^{-1}$)	0.0 – 3,000	0.0 – 3,000	0.0 – 4,000	0.0 – 2,000	400 – 1,800	500 – 1,400	900 – 2,200	200 – 1,300
NH_4-N (µg/L)	3.97 - 96	15.48 - 57.65	2.03 - 20.69	0 - 0.46	0.0 - 16.81	0.0 - 18.79	0.0 - 13.84	0.0 - 26.21
NO_2-N (µg/L)	8.0 - 9.3	8.0 - 9.3	8.4 - 10.2	8.9 - 10.2	0.2 - 7.07	0.0 - 3.45	0.56 - 2.01	0.0 - 1.64
NO_3-N (µg/L)	11.6 - 13.7	11.1 - 13.7	11.1 - 14.3	11.6 - 14.8	0.0 - 33.45	52.9 - 83.5	150.62 - 158.5	145.1 - 251.1
Tot-N (µg/L)	877.8 - 1655.6	766.7 - 544.4	877.8 - 1322.2	1211.1 - 2100	388.23 - 834.72	596.6 - 864.49	864.9 - 1013.32	N/A
Tot-P (µg/L)	78.7 - 145.3	65.3 - 132	105.3 - 125.3	92.0 - 152.0	5.81 - 161.77	63.36 - 83.79	67.08 - 80.08	59.65 - 76.36
SRP (µg/L)	13.2 - 23.2	13.2 - 24.8	23.2 - 29.9	14.8 - 24.8	0.0 - 5.81	0.2 - 18.8	7.66 - 37.57	5.81 - 24.37
TDP (µg/L)	18.33 - 27.22	25.0 - 33.89	25.0 - 33.89	23.89 - 31.67	0.0 - 3.95	0.0 - 5.81	13.23 - 24.35	16.95 - 31.80
Chl-a (µg/L)	0.0 - 7.0	2.1 - 6.3	0.0 - 4.2	2.1 - 2.8	22.9 - 53.5	18.77 - 25.02	8.34 - 24.3	1.39 - 63.94
Oil (mg/L)	0.1 - 3.9	0.1 - 5.3	0.4 - 1.4	11.3 - 12.50	0.13 - 0.29	0.21 - 0.27	0.22 - 0.63	0.23 - 0.66
H_2S (mg/L)	0.064 - 0.074	0.053 - 0.064	0.064 - 0.074	0.035 - 0.063	0	0	0	0
C_2H_2 (mg/L)	0.015 - 0.017	0.012 - 0.015	0.015 - 0.017	0.008 - 0.012	0	0	0	0
SRSi (µg/L)	237.2 - 372.2	167.2 - 395.5	260.5 - 677.2	222.2 - 421.56	167.1 - 269.5	198.5 - 279.5	216.7 - 224.7	219.97 - 421.56

Table 3.2. Comparison in the mean values of both the nutrients and physico chemical parameters at the four sampling stations of the Upper Victoria Nile

Variables	2006				2001			
	Kalange	Buyala	Kirindi	Namasagali	Kalange	Buyala	Kirindi	Namasagali
Cond. (μScm^{-1})	102.5	88.5	80	84.8	97.8	97.2	99.5	97.2
DO (mg/L)	4.2	6.3	6.5	6.1	7.38	7.47	8.2	7.16
Temp. (C)	26.7	26.4	26.7	26.5	26.39	26.33	26.58	26.11
pH	7	7.4	7.2	7	7.36	7.81	7.1	7.36
SD (m)	1.9	1.7		1.3	1.27	1.76	1.6	2.46
SS ($\mu g\ L^{-1}$)	2,000	2, 000	2,500	1,500	2,400	1,333.3	3,250	818.28
NH_4-N (µg/L)	42.26	29.45	8.62	0.46	1.26	6.77	3.76	5.85
NO_2-N (µg/L)	8.7	8.7	9	9.3	1.83	1.7	1.21	1.02
NO_3-N (µg/L)	12.5	12.6	12.7	12.9	8.68	66.05	154.14	203.73
Tot-N (µg/L)	1174	1192.5	1127.7	1544.4	585.15	699.12	574.27	868.74
Tot-P (µg/L)	108.6	100.8	118.6	118.6	64.38	71.35	85.27	74.04
SRP (µg/L)	19	19.2	27.1	21.2	0.29	4.23	15.46	15.09
TDP (µg/L)	23.1	28.3	30.2	27.4	64.38	71.35	85.27	74.04
Chl-a (µg/L)	3.7	4	3.4	2.4	26.86	21.34	8.48	14.73
Oil (mg/L)	6	8.9	4.7	11.7	0.21	0.24	0.35	0.5
H_2S (mg/L)	0.07	0.06	0.07	0.043	0	0	0	0
C_2H_2 (mg/L)	0.016	0.014	0.016	0.01	0	0	0	0
SRSi (µg/L)	319.9	309.4	443.6	494.3	236.57	219.8	243.43	296.53

3.3.2 Nutrients (NH_4-N, NO_2-N, NO_3-N, TN, Tot P, SRP, and SRSi) and pollutants (Oil, grease, H_2S and C_2H2)

At the Kalange, Buyala and Kirindi transects, the mean concentration of mean ammonium-nitrogen (NH_4-N) was generally higher in 2006 than in 2006. Additionally, NH_4-N showed a clearly decreasing trend downstream in 2006 while there was no clear pattern during the 2000 survey (Table 3.2). In Namasagali at all sampling points, very low concentrations of NO_4-H were detected. Along all transects, mean nitrite–nitrogen (NO_2-N) concentration was higher during the 2006 compared to that in 2000 (Table 3.2). While the concentration of NO_3-N was lower at all transects during the 2006 than the 2000 surveys, there was a general increasing trend of this nitrogen species along the stream flow (Table 3.2). Also noted was the higher concentration of TN during the 2006 than the 2000 survey. Low algal biomass (Chl-a) was recorded during the 2006 than the 2000 survey, and during both sampling events, there was no clear pattern along the stream flow.

Although the concentration of Total Dissolved Phosphorus (TDP) showed a generally increasing trend in the downstream direction, mean concentrations were lower (range of 23.1 to 30.2 µg L^{-1}) in 2006 than in 2000 (64.3 to 85.2 µg L^{-1}). However, concentrations of Total Phosphorus (TP) and Soluble Reactive Phosphorus (SRP) increased along the stream flow for both sampling events. Additionally, higher concentrations of TP and SRP were recorded during 2006 compared to the 2000 survey. Higher concentrations of silica were recorded during the 2006 than the 2000 survey, with concentrations generally increasing along the stream flow.

Data on grease and oil in addition to H_2S and C_2H_4 are given in Table 3.3. The concentration of oil and grease was higher in the 2006 samples than in those of 2000 by more than five fold. In the 2000 data, oil concentration increased in the downstream trend but no definite trend was noted in the 2006 data although the lower most transect (i.e. Namasagali) had the highest concentration. It was not possible to compare data on H_2S and C_2H_2 since these parameters were not assessed during the 2000 survey.

Table 3.3: Comparison in the mean values of oil and grease, hydrogen sulfide and methane at the four transects of the Upper Victoria Nile. (nd = not done).

	Year	Transects			
		Kalange	Buyala	Kirindi	Namasagali
Oil and grease	2006	6	8.9	4.7	11.7
(mg/l)	2000	0.21	0.24	0.35	0.5
H_2S (mg/l)	2006	0.07	0.06	0.07	0.04
	2000	nd	nd	nd	nd
C_2H_4 (mg/l)	2006	0.016	0.014	0.016	0.01
	2000	nd	nd	nd	nd

3.4. Discussion

The decreasing trend in the mean electrical conductance along the river could be attributed to reduction in the amount of rapids thus leading to settling of adsorbed ions on various particles in the water. However the range in conductivity values reflected the normal conductivity ranges of Lake Victoria waters.

The concentration of dissolved oxygen did not vary much among the four transects. However, dissolved oxygen increased in the downstream direction and could have been partly attributed to input from the atmosphere as a result of turbulence. In addition, as the water became calmer (reduced currents) along the stream flow, it was likely that the role of algae through photosynthesis became more important in recharging the system with oxygen. The higher algal biomass in 2000 could easily be related to the higher dissolved oxygen concentration in the water column compared to that determined during the 2006 survey. The low algal biomass (Chl-a) resulting into low primary production and productivity, is thought to have largely accounted for the low oxygen concentrations during April 2006.

Although some slight variations were noted, temperatures were generally higher than normal at all transects. It is likely that with the reduced water volume in the channel, the water column was receiving excess solar energy during the day thus leading to fairly high water temperatures. This could be the case since light penetration through the water column was down to the streambed at most sampling stations.

The wide range in pH in 2000 was probably due to the higher algal biomass at that time compared to that of 2006 bearing in mind the influence of algal photosynthesis on pH. The difference in secchi depth could be attributed in part to differences in the amount of suspended solids flowing downstream from Kalange as a result of landscape erosion by the fast flowing stream waters along the less vegetated river banks. Several stretches of the adjacent banks were devoid of natural vegetation due to clearing to give way to farmlands particularly crops. It was observed in this context that some slopes were so steep (> 45^{O}) that they were prone to severe erosion even with minimal rain events. Reduction in suspended solids along the stream flow could be a result of reduced stream currents thus allowing ample time for settling of particles.

The higher concentration of NH_4-N in the 2006 compared to that during the 2000 survey was probably an indication of a relatively degraded or deteriorating environment. This could be supported by the high concentrations of NO_2-N whose presence could imply the inability of the system to oxidize NO_2-N to NO_3-N. The decreasing trend in the concentration of NH_4-N downstream could be attributed to either loss through volatilization into the atmosphere or conversion to NO_2-N or uptake by microbes. In addition, the decreasing trend in the concentration of NO_3-N could also be attributed to the degrading environment resulting into rapid denitrification, or rapid biological uptake e.g. by algae and other microbes. Input of nutrients into the river through landscape erosion could be one of the major contributing factors to increased concentrations of nitrogen, phosphorus and silica in the water column compared to what was noted in 2000.

The high levels of oil and grease detected in April 2006 compared to 2000 was probably due to increased activities in the upstream reaches. Some of these activities could be increase use of outboard engines on the lake, tourism activities on the river, car washing or small spillages from the new dam. However, since there is no data on these activities, it is difficult to justify this statement. The higher concentration of oil and grease downstream at Namasagali could be a result of accumulation. Detection of some hydrogen sulphide (H_2S) and methane (C_2H_2) were evidence that the environment was relatively degraded. It is however, not possible to compare with the situation in the 2000 survey since these two parameters (H_2S and C_2H_2) were not determined.

3.5.1 Conclusions

Although some parameters such as electrical conductance and temperature did not show much variance during the two survey periods, a relative shift in most of the water quality parameters was noted. The noted shifts were reduced dissolved oxygen coupled with a reduction in algal biomass. Others included an increase in the amount of suspended solids, increase in nutrients (N, P & Si), and increase in the amount of oil and grease. In addition, detection of hydrogen sulphide, methane, ammonium-nitrogen and nitrite-nitrogen were indications of a deteriorating water environment. The results presented in this report are preliminary hence need more data to enable detailed analysis and interpretation in order to come up with sound scientific recommendations.

CHAPTER 4

4.0. Algal Biomass and Species Composition

4.1. Introduction

Algae are major primary producers in aquatic systems by harnessing solar energy in the presence of chlorophyll and carbondioxide, form carbohydrates that can then be tapped directly by primary consumers or indirectly by secondary consumers. This process, sometimes referred to as photosynthesis, also aerates aquatic systems with oxygen as its by-product, thus making such systems habitable to a range of aquatic organisms including fish. Algae is also an important food in aquatic food webs hence sustainability of this resource is crucial to proper management. Changes in the water environment will alter the composition and abundance of the algal communities and may lead to changes in fish species abundance and species composition. A survey of algal communities of the Upper Victoria Nile was carried out between 6-13th April 2006 in four transects (1-Kalange-Makwanzi, -2 Buyala-Kikubamutwe, 3 -Kirindi-Matumu, and 4- Namasagali-Bunyamira) along the river to determine the species composition, distribution and biomass (Chlorophyll-a).

4.2. Materials and methods

Water samples from the four transects along the Nile were taken using a van dorn sampler. Lugols solution was used as preservative immediately after sampling. Algal biomass as chlorophyll-a was determined by filtering water through a 0.45µm pore size GF/C filter papers and using methanol as an extract (Stainton, 1977); FIRRI lab manual 1996).

In the laboratory 2 mls of the sample was put in Sedgewick counting chamber and allowed to settle for three hours. Algal composition was determined using an inverted microscope at 400X magnification.

4.3. Results

Five major taxonomic groups of algae (Blue-green, Diatoms, Chlorophyta, Cryptophyta and Euglenophyta) constituted the algal community in the four sampled transects along the Upper Victoria Nile (Table 4.1). The blue-green algae were dominant at all transects with Kirindi exhibiting the highest percentage while the green algae and the diatoms were consistently low (Table 4.1). The blue-green algae of the genera *Anabaena, Aphanocapsa, Merismopedia, Planktolyngbya* and the green algae of the genera *Ankistrodesmus, Closterium and Pediastrum* occurred in all the transects. The species number increased progressively from the previous sampling of 2000 with Namasagali transect recording the highest number of species (50) compared to the other three transects (Table 4.2).

4.4. Discussion

The algal taxonomic composition was similar to that of lake Victoria and was comparable to the previous AESNP survey of 2000 which was curried out in the same month. Blue green algae dominated in all the transects but there was no significant difference in the species composition with in the transects in this group. The dominance of blue green algae at all sites may be an indication of declining water quality, resulting from nutrient loads that could be coming from the extensive agricultural activities in the sub-catchments along the Nile. The occurrence of nitrogen fixing algae *Anabaena* in all the sites could be an indication of a system that has already started suffering from nitrogen deficiency and this is likely to affect the fishery of the river.

4.5. Conclusion

Five major taxonomic groups of algae (Blue green, Diatoms, Chlorophyta, Cryptophyta and Euglenophyta) constituted the algal community of the Upper Victoria Nile with the blue-green algae of the genera *Anabaena, Aphanocapsa, Merismopedia, Planktolyngbya* dominating in all the transects

The continued influx of nutrients into the river from the catchment may have consequences for algal species composition, which in turn could affect the structure and composition of higher trophic levels

Table 4.1. Numerical abundance (%) of the major algal taxonomic groups in the four transects

Transect	Stations	Blue-Green (%)	Diatoms (%)	Chlorophyta (%)	Cryptophyta (%)	Euglenophyta (%)
Kalange	East	86.36	2.25	11.24	0.15	
	Middle	85.46	3.86	10.39	0.3	
	West	83.73	4.13	11.89	0.13	0.13
Kikubamutwe	East	96.57	1.27	2.03	0.06	0.06
	Middle	85.86	1.63	12.27	0.13	0.13
	West	92.82	2.01	5.09	0.08	
Kirindi	East	97.5	1.25	1.25		
	Middle	97.67	1.85	0.48		
	West	98.56	0.42	1.01		
Namasagali	East	89.85	1.94	8.10		
	Middle	85.74	13.16	0.55		0.55
	West	57.11	2.24	3.47		

Table 4.2. Checklist of the algal species composition from the four sampled transects

Class	Kalenge	Kikubamutwe	Kirindi	Namasagali
Blue-green				
Anabaena circinalis	X	X	X	X
Aphanocapsa decatissima	X		X	X
Aphanocapsa incerta	X			
Aphanocapsa sp	X	X	X	X
Chroococcus dispersus	X	X		
Chroococcus turgidus			X	X
Chroococcus limeticus	X		X	X
Chroococcus sp	X	X		X
Ceolomoron sp			X	X
Gloeococcus sp				X
Ceolosphaerium sp			X	
Cylindrospermopsis africana	X	X		
Cylindrospermopsis cupsis	X			
Cylindrospermopsis sp	X	X		
Cyanodycton sp			X	X
Merismopedia glauca	X	X		X
Merismopedia tenuissima	X	X	X	X
Merismopedia elagans			X	
Microcystis flos-aqaue	X	X	X	
Microcystis sp	X	X		
Planktolyngbya circumcreta	X	X	X	X
Planktolyngbya contarta	X	X		
Planktolyngbya limnetica	X	X		X
Planktolyngbya tallingii	X	X	X	X
Romeria gracile	X	X		
Rhodomonas sp	X	X		
Diatoms				
Cyclostephanodiscus sp	X	X	X	
Cyclotella sp	X	X	X	
Navicula gastrum	X			
Navicula sp			X	X
Navicula lacoelata				X
Navicula radiosa	X	X		
Nitzschia acicularis	X	X	X	X
Nitzschia mediocris				X
Nitzschia fonticola	X	X	X	X
Synedra cunningtonii		X		
Cocconeis sp				X
Centric diatoms			X	X
Euglenophyta				
Euglena acus	X			
Trachelomonas sp		X		X

Class	Kalenge	Kikubamutwe	Kirindi	Namasagali
Green Algae				
Ankistrodesmus falcatus	X	X	X	X
Ankistrodesmus fusuformis	X	X		
Ankistrodesmus setigera				X
Chodetella sp		X	X	X
Chodetella subsala			X	
Closterium acicularis	X	X		
Closterium sp	X	X	X	X
Dictyosphaerium sp				X
Kircheriella obesa	X	X	X	X
Botryococcus braunii				X
Monoraphidium contartum	X	X		X
Monoraphidium sp			X	X
Dydmocystis sp			X	
Oosystis sp				X
Oocytistis lucutris	X	X		
Oocytistis soltaria	X			
Oocytistis borgei				X
Pediastrum boryanum				X
Pediastrum dumplex	X	X		X
Pediastrum simplex	X	X	X	X
Pediastrum tetras		X		
Selenastrum gracile				X
Scenedesmus acuminatus	X	X		X
Scenedesmus armatus			X	X
Staurastrum curvatum				X
Scenedesmus bijugatus				X
Scenedesmus arcuatus	X	X		X
Scenedemus apiculatus				X
Scenedesmus quadricuada	X	X		
Scenedesmus perforatus				X
Shroederia setigera				X
Scenedesmus sp	X	X		X
Scenedesmus castato			X	
Stuarastrum cuspdatum	X			
Stuarastrum gracile	X	X		
Stuarastrum sp		X		
Crucigenia fenestrata			X	X
Crucigenia sp				X
Coelastrum sp	X	X		X
Dinoflagelletes				
Glenodinium sp				X
Species	**44**	**41**	**30**	**50**

CHAPTER 5

5.0. Aquatic Macrophytes

5.1. Introduction

Human activities have transformed the catchment area of the River Nile to the extent that the original landscape is not recognized in most sections of the riverbanks. The original vegetation has mostly been replaced with crop cover, and to a smaller extent grazing of domestic animals. Due to the steep slopes in most sections of the riverbank, conversion of the landscape to agricultural land has left the slopes bare, exposing the soils to various forms of erosion (Plate 5.1).

Plate 5.1: Cultivation at the river bank down to the watermark

Areas most denuded of natural vegetation are those in the upstream reaches of Kalange-Makwanzi, Buyala-Kikubamutwe and Kirindi-Matumu transects. Further downstream, the areas around the Namasagali-Bunyamira transect were relatively better vegetated.

Given the significantly low 2006 water levels in the stream channel that has led to exposure of formerly shallow areas, some aquatic plants had rapidly started colonizing the exposed sections of the river with opportunistic plants. Exposure of shallow areas (Plate 5.2) would imply enhanced biogeochemical cycles that are likely to lead to enhanced availability of nutrients (Barbanti *et al.*, 1992; Bates & Neafus, 1980; Bostrom & Petterson, 1982; James *et al.*, 1996) that foster plant growth. Colonization by plants at exposed sites is also thought to have been favored by the assumed nutrient-rich guano from aquatic birds around shallow rocky areas (Plate 5.3).

Plate 5.2. Exposed shallow zone of the river bank at Kikubamutwe

This study was intended to provide baseline information on the diversity and relative cover abundance of aquatic macrophytes in the four transects of Kalange-Makwanzi, Buyala-Kikubamutwe, Kirindi-Matumu and Namasagali-Bunyamira. This information is to form part of the baseline data upon which future ESIAs are to refer to.

Plate 5.3: An exposed rock with guano from aquatic birds

5.2. Study area

This study was undertaken at the same four transects as used in 2000, namely 1-Kalange-Makwanzi, 2- Buyala-Kikubamutwe, 3- Kirindi-Matumu, and 4- Namasagali-Bunyamira between 6th – 13th April 2006.

5.3. Materials and methods

Sampling sites were georeferenced using a GPS hand set (GARMIN 175), with coordinate references recorded in decimal degrees. Water based surveys were conducted on a motorized boat along the shores of the riverbanks and around islands wherever they occurred. Stretches of 300 m were determined and all species of aquatic macrophytes were recorded; data on macrophyte abundance was determined by three independent observations and the mean evaluation was agreed on. The evaluation of abundance was at five levels i.e. dominant, abundant, frequent, occasional and rare (DAFOR). Those plants that could not be identified on site were pressed and kept for exact identification at some later date, preferably from Makerere University herbarium. A checklist was then prepared to determine the presence or absence of these plants.

5.4. Results

The determination of macrophyte presence based on the DAFOR system is presented in Table 5.1. Though variations occurred among sites, it was found that water hyacinth was ubiquitous despite variations in its occurrence based on the DAFOR system. In an ascending order of species diversity, Kalange-Makwanzi had 6, Kirindi-Matumu had 13, Kikubamutwe-Buyala had 15 and Namasagali-Bunyamira had 37 (Fig. 5.1).

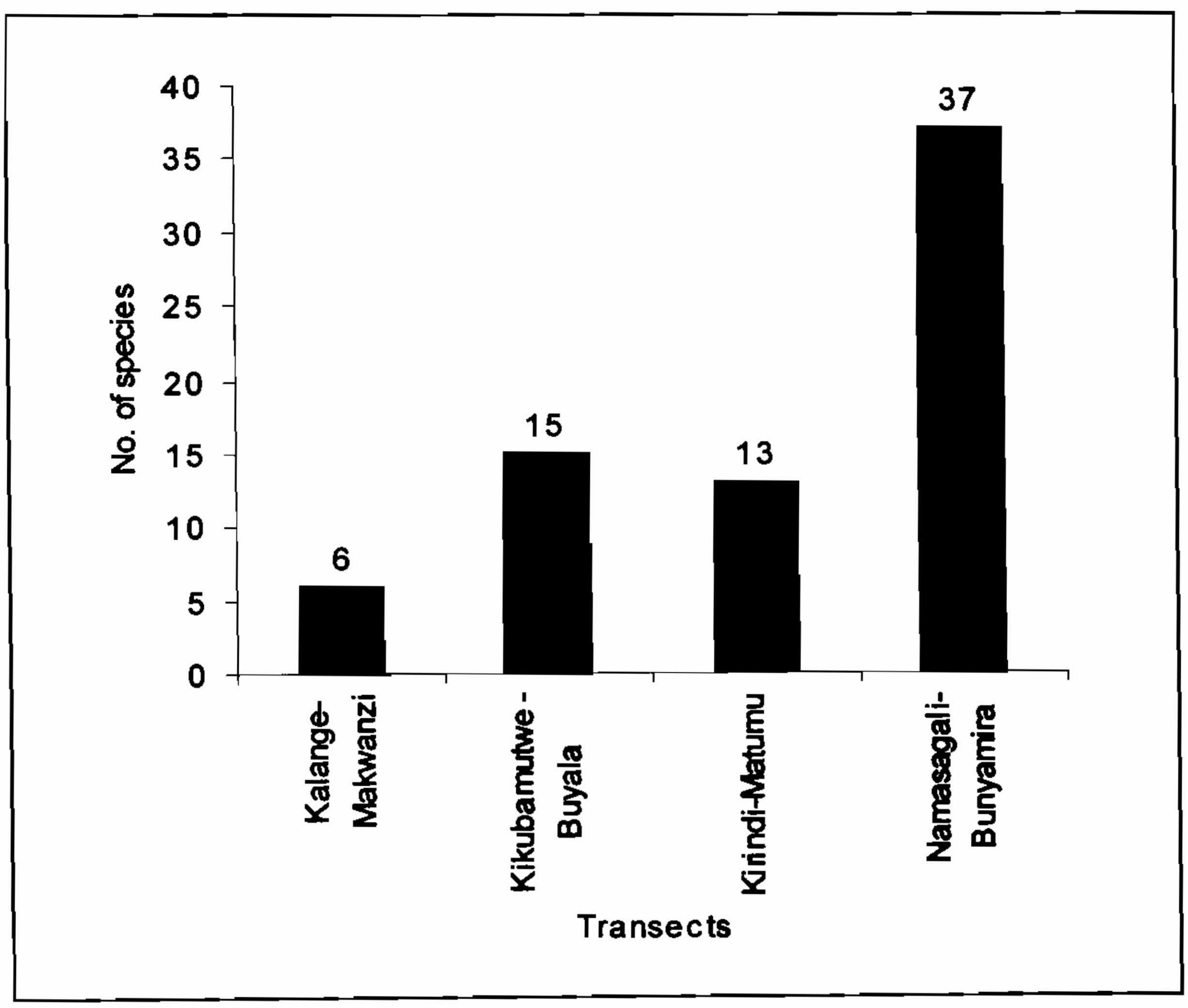


Fig. 5.1: Diversity of aquatic macrophyte species at the four transects

Description of macrophyte occurrence at the transects

5.4.1. Kalange-Makwanzi (Transect 1)

Four sites were sampled at this transect, with replicates of A, B and C i.e. Bubaale, Mukikonko, and Kuntukulu 1 and Kuntukulu 2. This transect was characterized by very steep banks on either side, with the eastern section more cultivated compared to the western part that was mainly a residential area. At Bubaale, the order of occurrence of aquatic macrophytes was such that *Vossia cuspidata* was dominant, *Eichhornia crassipes* was frequent, while *Pistia stratiotes* was rare. At Mukikonko, similar observations as at Bubaale were made; with *V. cuspidata* being the dominant plant, while *Eichhornia crassipes* and *Pistia stratiotes* were frequent and rare, respectively. Other plants that were present were majorly rare and included some climbers locally called libombwe, in addition to *Ipomoea aquatica*. Around the Kuntukulu Island, *V. cuspidata* was frequent, *E. crassipes* was rare, while other were rare and included *Ipomoea aquatica*, *Polygonum* sp., and some unidentified climbers locally called Musasizi. The riverbanks on the western side were denuded of aquatic plants and instead colonized by a weedy tree locally called Nkulaidho. At all these sites, a plant belonging to Asteraceae (Compositae) was present but rare.

5.4.2. Kikubamutwe-Buyala (Transect 2)

This transect was characterized by cultivation down to the watermark, thus exposing the banks to erosion by rain. Sites sampled at this transect were Kikubamutwe A and B on the western side, and Buyala A, B and C on the east. On the western side, *V. cuspidata* was abundant and *E. crassipes* was frequent. Other macrophytes such as *Ipomoea* spp., sedges, *P. stratiotes*, *Lemna* sp., and some genera belonging to the family Asteraceae were occasional. Among the rare plants were *Ficus* sp. and some species belong to Asteraceae.

On the eastern portion of the transect (Buyala), with common plants being *E. crassipes* and *V. cuspidata*. The former ranged from abundant to dominant, while the latter from rare to frequent. Other macrophytes were rare and included some sedges, *Leisia lexadra* and *Lemna* sp.

5.4.3. Kirindi-Matumu (Transect 3)

Like at the Kikubamutwe-Buyala transect, this area was characterized by cultivation down to the watermark, thus making the landscape vulnerable to rain erosion. Sites sampled were Kirindi A and B, Damba on the western part in addition to Nankandulo A and B on the east. On the western part of the transect, *V. cuspidata* ranged from frequent to abundant. Plants that occurred frequently were *Hydrocotyle ranunculoides* and *Cyperus mundti,* while those that were occasional included *E. crassipes*, *Phragmites mauritianus*, *Lemna* sp. and *Azolla africana*. Others such as *Ludwigia* sp., *Ipomoea* sp., *Sesbania sesban*, some climbers, some species of Asteraceae, sedges, and *P. stratiotes* were rare.

On the east of the transect, *V. cuspidata* and *E. crassipes* were locally abundant, while occasionally occurring plants included *S. sesban*, *P. mauritianus*, and sedges. The rest of the plants were rare and included species of Asteraceae, *Cyperus papyrus* and *I. aquatica*.

5.4.4. Namasagali-Bunyamira

This transect had the highest diversity of aquatic macrophytes probably because of its fairly quiescent waters. The sites sampled were Nsangabiyire and Kasimwe A and B on the east, and Lwabyata A and B and Bunyamira to the west. The landscape on either side of the river was relatively well covered with vegetation compared to the other three transects. There were extensive stretches of swamp with *C. papyrus* as the dominant macrophyte (Plate 5.4). *E. crassipes* on the other hand was the abundant macrophyte (Plate 5.4)

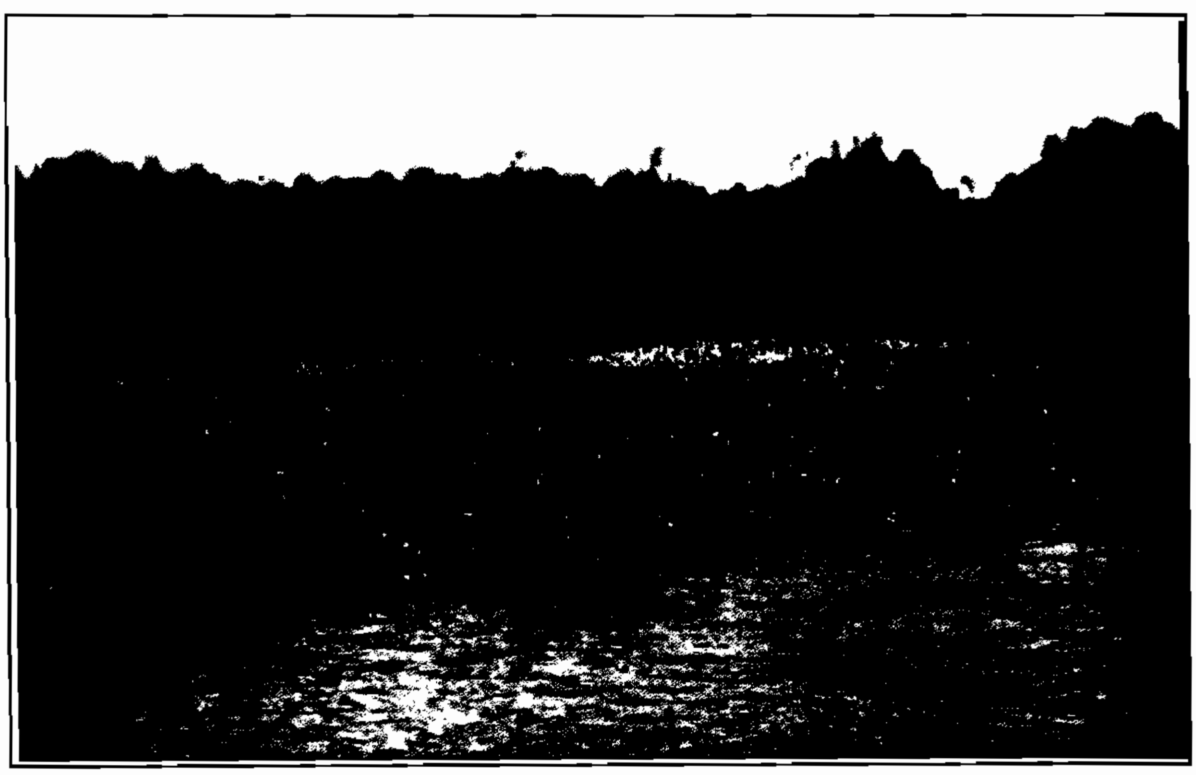


Plate 5.4. An extensive fringe of *E. crassipes* with a papyrus background

Those macrophytes that were frequent included *Ceratophyllum demersum*, *Vallisneria* sp. and *Nymphaea* sp. on the eastern side; on the west were *C. papyrus*, *P. mauritianum*, *Commelina* sp., *Polygonum* sp. Plants that occurred occasionally on the east were *Azolla africana*, *Cayratia ibuensis*, *Polygonum* sp., *Lemna* sp., *Vallisneria* sp., *Cayratia ibuensis* and *C. mundtii*, while on the west were *E. crassipes*, *S. seban*. *Sudia sagitifolia*, *C. demersum*, *Nymphaea* sp., *Najas horrida*, *Lemna* sp., *A. africana*, *Vallisneria* sp., *Cayratia ibuensis*, *C. demersum*, *Nymphaea* sp. and *Polygonum* sp. Several rare plants were identified and on the east were *Lemna* sp., *N. horrida*, *H. verticilata*, *C. bengalensis*, *P. stratiotes*, *V. cuspidata*, *Polygonum* sp., *Virginia* sp. On western side of the river, rare plants included some members of Asteraceae, *C. bengalensis*, *H. verticilata*, *C. mundtii*, *P. stratiotes*, *Sudia* sp., *V. cuspidata*, *Vallisneria* sp., *Lemna* sp. and *A. africana*.

5.5. Discussion

The observed recession in water levels has resulted into expansion of the aquatic macrophyte bed into the river channel, with exposed areas being colonized by opportunistic plants that were characteristic of muddy substrates. Exposure of sediments is known to result into enhanced nutrient release (Barbanti *et al.*, 1992; Bates & Neafus, 1980; Bostrom & Petterson, 1982; James *et al.*, 1996), a process that likely contributed to the expanded vegetated zones. In addition, low water levels led to exposure of rocks that formed ideal perching sites for various water fowl; their guano is assumed to contribute to nutrient enrichment of the system hence favoring rapid colonization of aquatic plants at exposed sites.

A total of 41 species of aquatic macrophytes were encountered (Table 5.1). Despite this diversity, the Kalange-Makwanzi transect had the lowest number of species (maximum of only 6), followed by Kirindi-Matumu transect with 13 species, Buyala-Kikubamutwe with 15 species, while Namasagali-Bunyamira transect registered the highest diversity of 37 macrophyte species. This was likely reflecting the level of human interference on the landscape, with Namasagali-Bunyamira area being the least disturbed hence highest macrophyte species.

5.6. Conclusions

The diversity of aquatic macrophytes was more than twice higher at the Namasagali-Bunyamira transect compared to that at the other three transects. This contrasts sharply from the conclusion made during the former surveys under AES Nile Power (2000). This assumed significant difference could be attributed to the low survey coverage that was done at the Namasagali-Bunyamira transect during 2000. Additionally, the low water levels that have characterized the river led to cultivation along some stretches down to the water mark thus leading to destruction of established macrophyte beds; this was especially so along the Buyala-Kikubamutwe, Kirindi-Matumu and to a lesser extent at the Kalange-Makwanzi transects. It is also possible that the draw down of the river water volume left some sites bare of water hence could have resulted into disappearance of some aquatic macrophytes previously encountered.

Table 5.1a: Check list for aquatic macrophytes at the four transects

SITE	*Vossia cuspidata*	*Eichhonia crassipes*	*Pistia stratiotes*	*Lemna trisulca*	*Polygonum satulosum*	*Ipomea aquatica*	*Commelina bengalesis*	*Ipomea rubens*	*Enhyndra feactuens*	*Sesbania sesban*	*Mikania cordata*	*Amaranthus dibuis*
Kalange-Bubale A	A	F	_	_	_	R	_	R	_	_	_	_
Kalange-Bubale B	A	F	R	_	_	R	_	_	_	_	_	_
Kalange-Bubale C	A	F	R	_	_	R	R	_	_	_	_	R
Kalange-mukikonkoA	A	F	R	_	_	R	_	_	_	_	R	_
Kalange-Mukikonko B	A	F	R	_	_	R	_	_	_	_	_	_
Kalange-Mukikonko C	R	A	_	F	_	_	_	_	_	_	_	_
Kalange-Kuntuukulu A	F	O	_	_	A	R	_	_	_	_	R	_
Kikubamutwe Landing A	A	R	R	_	A	R	R	R	R	R	R	R
Kikubamutwe Landing B	A	F	_	_	A	_	_	_	_	_	_	_
Kikubamutwe Landing A	A	A	R	R	_	_	_	_	_	_	R	_
Kikubamutwe-landing B	O	F	_	_	_	_	_	_	_	_	_	_
Kikubamutwe Landing C	F	_	_	R	_	_	_	_	_	_	_	_
Kirindi-Kirindi A	A	R	_	_	_	_	_	_	R	R	_	_
Kirindi-Kirindi B	F	R	_	R	_	_	_	_	R	_	R	_
Kirindi-Damba A	A	F	R	_	_	_	_	_	R	_	_	_
Kirindi-Nankandulo A	F	R	_	_	_	_	_	_	_	_	R	_
Kirindi-Nakandulo B	A	A	_	_	_	_	R	R	_	R	R	_
Namasangali-Nsangabiyire A	R	A	R	R	A	_	R	_	_	_	R	_
Namasangali-Kasimwe A	R	A	R	R	A	_	R	_	_	_	_	_
Namasangali-Kasimwe B	R	A	R	R	R	_	_	_	_	_	_	_
Namasangali-Kaita A	R	R	_	_	_	_	F	_	_	R	R	_
Namasangali-Lwabyanta A	_	A	R	R	F	_	R	_	_	_	_	_
Namasangali-Bunyamira A	R	A	R	10	R	_	_	_	_	_	_	_

Table 5.1b

SITE	*Leersea hexadra*	*Solanum nigrum*	*Cyperus pectinantus*	*Ficus amadiensis*	*Cyperus munditii*	*Hydrocotyle ranunculoides*	*Phragmitas australis*	*Azolla pinnata*	*Punchea diascoridis*	*Varnonia amygdalina*	*Sarcocephalus latifolius*
Kalange-Bubale A	_	_	_	_	_	_	_	_	_	_	_
Kalange-Bubale B	_	_	_	_	_	_	_	_	_	_	_
Kalange-Bubale C	_	_	_	_	_	_	_	_	_	_	_
Kalange-mukikonkoA	_	_	_	_	_	_	_	_	_	_	_
Kalange-Mukikonko B	_	_	_	_	_	_	_	_	_	_	_
Kalange-Mukikonko C	_	_	_	_	_	_	_	_	_	_	_
Kalange-Kuntuukulu A	_	_	_	_	_	_	_	_	_	_	_
Kikubamutwe Landing A	R	R	R	R	_	_	_	_	_	_	_
Kikubamutwe Landing B	_	_	_	_	_	_	_	_	_	_	_
Kikubamutwe Landing A	_	_	_	_	_	_	_	_	R	_	_
Kikubamutwe-landingB	R	_	O	_	_	_	_	_	_	_	_
Kikubamutwe Landing C	R	_	R	_	_	_	O	_	_	_	_
Kirindi-Kirindi A	_	_	_	_	F	F	R	_	_	R	R
Kirindi-Kirindi B	_	_	_	_	R	F	R	R	_	R	R
Kirindi-Damba A	_	_	R	_	_	_	_	_	_	_	R
Kirindi-Nankandulo A	_	_	O	_	R	_	_	R	F	_	_
Kirindi-Nakandulo B	_	_	R	_	_	_	R	R	_	_	_
Namasangali-Nsangabiyire A	_	_	R	_	R	R	_	R	_	_	_
Namasangali-Kasimwe A	_	_	R	_	R	_	R	R	R	_	_
Namasangali-Kasimwe B	_	_	R	_	R	R	_	R	R	_	_
Namasangali-Kaita A	_	_	R	_	R	_	F	_	_	_	R
Namasangali-Lwabyanta A	_	_	R	_	R	_	_	_	_	R	_
Namasangali-Bunyamira A	R	R	R	R	R	_	_	R	_	_	_

Table 5.1c

SITE	*Mondia whytei*	*Psychetia sesensis*	*Ludwigia stolonifera*	*Cyperus papyrus*	*Phoenix reclinata*	*Najas horrida*	*Hydrilla verticilata*	*Vallisneria americana*	*Europhia harsfarthii*	*N. lotus*	*Cayratia ibuensis*	*C. demersum*	*Hibiscus diversifolia*
Kalange-Bubale A	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalange-Bubale B	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalange-Bubale C	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalange-mukikonkoA	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalange-Mukikonko B	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalange-Mukikonko C	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalange-Kuntuukulu A	-	-	-	-	-	-	-	-	-	-	-	-	-
Kikubamutwe Landing A	-	-	-	-	-	-	-	-	-	-	-	-	-
Kikubamutwe Landing B	-	-	-	-	-	-	-	-	-	-	-	-	-
Kikubamutwe Landing A	-	-	-	-	-	-	-	-	-	-	-	-	-
Kikubamutwe-landing B	-	-	-	-	-	-	-	-	-	-	-	-	-
Kikubamutwe Landing C	-	-	-	-	-	-	-	-	-	-	-	-	-
Kirindi-Kirindi A	R	R	-	-	-	-	-	-	-	-	-	-	-
Kirindi-Kirindi B	R	R	-	-	-	-	-	-	-	-	-	-	-
Kirindi-Damba A	-	R	-	-	-	-	-	-	-	-	-	-	-
Kirindi-Nankandulo A	-	-	R	-	-	-	-	-	-	-	-	-	-
Kirindi-Nakandulo B	-	-	-	R	-	-	-	-	-	-	-	-	-
Namasangali-Nsangabiyire A	-	-	R	D	-	R	R	F	R	F	R	F	R
Namasangali-Kasimwe A	-	-	R	D	-	R	R	R	R	-	R	-	-
Namasangali-Kasimwe B	-	-	R	D	-	-	-	R	R	-	R	-	-
Namasangali-Kaita A	-	-	R	F	-	-	-	-	R	-	-	-	-
Namasangali-Lwabyanta A	-	-	R	D	-	R	R	R	R	D	R	R	-
Namasangali-Bunyamira A	-	-	R	A	-	-	R	R	R	R	R	R	-

Key to codes:

D: Dominant
A: Abundant
F: Frequent
O: Occasional
R: Rare
-: Absent

CHAPTER 6

6.0. Micro-invertebrates Fauna

6.1. Background

A hydropower plant is planned to be built at Bujagali site located in the upper reaches of the Victoria Nile near Jinja. The status and dynamics of micro-invertebrate (zooplankton) fauna constitutes part of the investigations within a broad study of the fisheries and environment of the river prior to construction of the hydropower station. The study is intended to provide a basis for evaluating the impact of the project on the environment and the biological resources associated with it.

This report presents results on the micro-invertebrate/zooplankton community of the first quarter field sample collections from one site upstream and three sites downstream of Dumbbell Island, the proposed site of the power plant. This study was conducted between 6^{th} – 13^{th} April 2006, and comparison with data from April 2000 are made.

6.2. Materials and methods

Four study/sampling sites are located at Kalange upstream of Dumbbell, Buyala, Kilindi and Namasagali; all lying at increasing distances downstream of the proposed dam site (Fig. 2.1a). The same transects were sampled during April 2000.

Zooplankton were sampled using conical nets of the Nansen type, having a 0.25m mouth diameter and with a 60 µm nitex mesh size net. At each sampling site, one transect was established with five sampling points (except Kirindi and Namasagali which had three) covering as much as possible, the river width. For ease of sampling in running water conditions, sampling points were generally located in areas of low water currents i.e. downstream of islands or rocky outcrops or quiescent bays. At each sampling point, three vertical hauls were taken from about 0.5m above the riverbed and combined to make a composite sample. The samples were preserved in 4% sugar formalin solution (to stop 'ballooning' of Cladocera and consequent loss of contents of the brooding pouch). In the laboratory, each sample was placed in a clean glass beaker and diluted to a suitable volume (depending on the numerical concentration of the organism). Sub-samples of 2 and 5ml were taken from a well-mixed sample using a calibrated bulb pipette, placed on a counting chamber and examined under an inverted microscope (mag. X 20). The organisms were taxonomically identified to species level (adults only) using appropriate identification keys for Copepoda, Cladocera and Rotifera) and count data of the different taxa compiled.

6.3. Results

6.3.1. Faunal composition and frequency of occurrence

The zooplankton community was composed of six species of Cyclopoid copepods, one species of Calanoid copepods, seven species of Cladocera and 12 species of Rotifera (Table 6.1). The most frequent taxa in the samples were *Thermodiaptomus galeboides* (69%), *Thermocyclops neglectus* (62%), *Tropocyclops confinnis* (75%), *Tropocyclops tennelus* (75%), copepodite and naupliar growth stages of copepods (>75%), *Bosmina longirostris* (63%) and *Keratella tropica* (75%). Rare taxa (<10%) included *Ceriodaphnia cornuta*, *Daphnia lumholtzi*, *Macrothrix* sp., and several species of Rotifera.

Table 6.1. Checklist of zooplankton taxa encountered in samples from sites along four transects in Upper Victoria Nile, April 2006.

	Transect 1(Upstream) Kalange to Makwanzi					Transect 2 (Downstream) Buyala to				Transect 3 (Downstream)			Transect 4 (Downstream) Namasagali to				
Sites	Kalange 1	Kalange 2	Kalange 3	Kalange 4	Kalange 5	Mukisoga	Mugalya	Mukisaija	Kazinga	Edge	Mutuma middle	Mutuma edge	Rwabyata inshore	Rwabyata	Nsangabwire egde	Nsangabwire off	Frequency of occurrence
Copepoda																	
Thermodiaptomus galeboides	P	P	P	P	P	P	P	A	P	A	P	P	A	A	P	A	68.8
Mesocyclops sp.	P	P	P	A	P	A	A	P	A	A	A	P	A	A	A	P	43.8
Thermocyclops emini	A	P	A	P	P	P	A	P	A	A	A	A	A	A	A	A	31.3
Thermocyclops incisus	A	A	A	A	A	P	A	P	P	A	A	A	A	A	A	A	18.8
Thermocyclops neglectus	P	P	P	P	P	P	P	P	P	A	A	P	A	A	A	A	62.5
Tropocyclops confinnis	P	P	P	P	P	P	A	P	P	P	P	A	P	P	A	A	75.0
Tropocyclops tenellus	P	P	P	P	P	P	A	P	P	A	P	A	P	P	A	P	75.0
Calanoid copepodites	P	P	P	P	P	P	P	P	P	P	P	A	A	P	A	A	75.0
Cyclopoid copepodite	P	P	P	P	P	P	P	P	A	P	P	A	P	P	P	P	87.5
Nauplius larvae	P	P	P	P	P	P	P	P	P	P	P	A	P	A	P	P	87.5
Cladocera																	
Bosmina longirostris	P	P	P	P	P	A	A	A	P	P	A	P	A	P	A	P	62.5
Ceriodaphnia comuta	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	A	6.3
Daphnia lumholtzi	A	A	A	A	A	A	A	A	A	A	A	A	A	A	P	A	6.3
Daphnia lumholtzi(helm)	A	A	P	P	A	P	A	P	P	A	A	A	A	A	A	A	31.3
Diaphanosoma excisum	P	A	P	P	P	A	A	A	A	A	A	A	A	A	A	A	25.0
Moina micrura	A	P	A	P	P	A	A	A	A	A	A	A	A	A	A	P	25.0
Macrothrix sp.	A	A	A	A	A	A	A	A	A	A	P	A	A	A	A	A	6.3
Chydorus sp.	A	A	A	P	A	A	A	A	A	P	A	A	A	A	A	A	12.5
Rotifera																	
Brachionus angularis	A	P	P	A	A	P	A	P	A	A	A	A	P	A	A	A	31.3
Brachionus calyciflorus	P	A	P	P	P	A	A	A	P	P	A	A	A	P	A	A	43.8
Brachionus falcatus	A	A	A	A	A	A	A	A	P	A	A	A	A	A	A	A	6.3
Euclanis sp	A	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	6.3
Filinia longiseta	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	6.3
Filinia opoliensis	A	P	A	A	A	A	A	A	A	A	A	A	A	A	A	A	6.3
Keratella cochlearis	P	A	P	P	P	A	P	P	A	A	A	P	A	A	A	A	43.8
Keratella tropica	P	A	P	P	P	P	P	P	A	P	P	P	A	P	A	P	75.0
Lecane bulla	P	A	P	P	A	A	A	A	P	A	A	P	A	A	A	P	37.5
Polyarthra sp.	A	A	A	P	A	A	A	A	A	A	A	A	A	A	A	A	6.3
Synchaeta sp.	P	P	P	A	P	A	A	A	P	A	A	A	A	A	A	A	31.3
Trichocerca cylindrica	P	P	P	A	A	A	A	P	A	A	A	A	A	A	A	A	25.0

Elements of some macro-invertebrate community such as chaoborid and chironomid larvae, *Caridina nilotica* etc. that were caught along with zooplankton were eliminated from the present analysis.

6.3.2. Species richness

Species richness generally decreased with increasing distance downstream (Fig. 6.2). There was considerable variation in species richness exhibited by the three broad taxonomic groups between and within sampled sites. Upstream sites supported up to 6-8 species of Copepoda, Cladocera and Rotifera while downstream sites had at most 2-3 species.

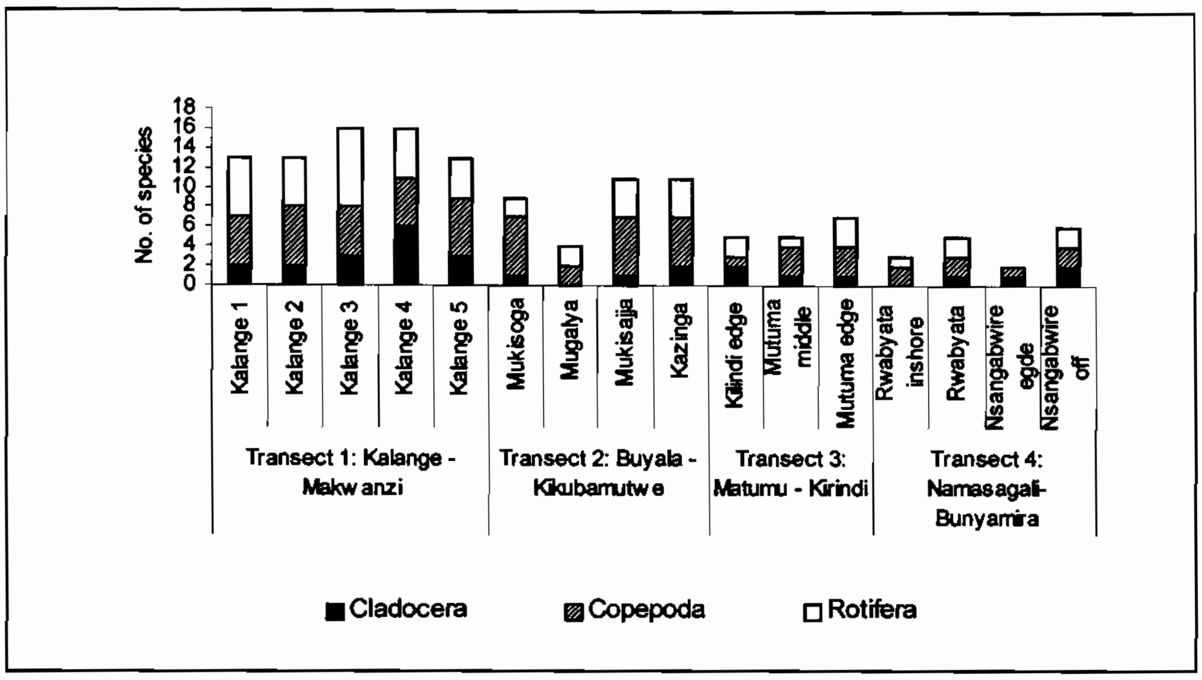


Fig. 6.2. Zooplankton species richness at sampled sites along four transects in Upper Victoria Nile April 2006.

6.3.3. Zooplankton distribution, densities and relative abundance

Most cyclopoid copepod taxa exhibited wide distribution being recovered at most sites especially in the upstream section of the sample area (Table 6.1, Fig. 6.3). Cladoceran and Rotiferan taxa, however, showed discontinuous distribution patterns throughout the sample area. *Keratella tropica*, exhibited the highest frequency of occurrence (75%) among rotiferan species.

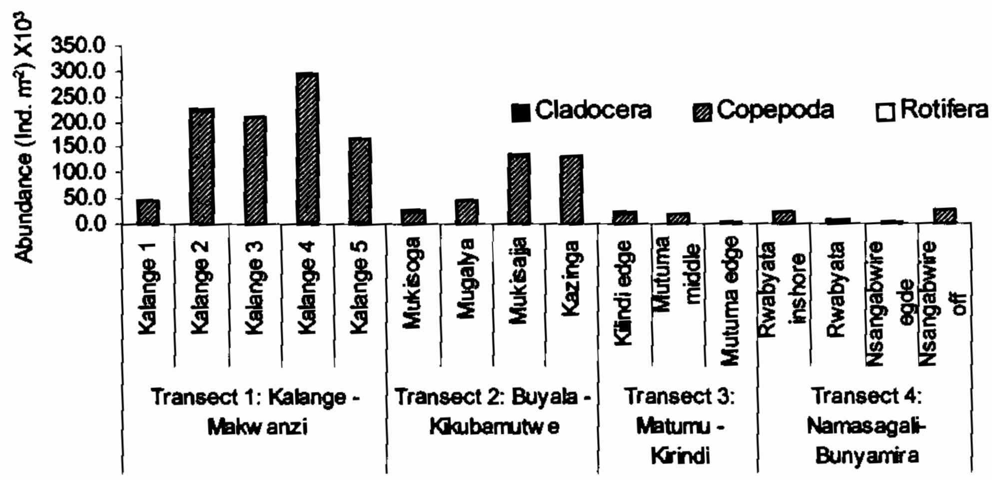


Fig. 6.3. Numerical abundance of zooplankton taxa at selected sampled sites along transects in Upper Victoria Nile, April 2006.

Copepod taxa generally exhibited higher abundance estimates (up to 290,000 indiv. m^{-2}) especially in the upstream sites between Kalange-Makwanzi and Buyala-Kikubamutwe (Fig. 6.3, Table 6.2). Other taxa occurred with generally much lower abundance (<5000 indiv m^{-2}) at most sites.

Table 6.2. Mean percentage composition of zooplankton taxa at the four sampling stations/transects along Upper Victoria Nile between Kalange and Namasagali, April 2006. Numbers in parentheses refer to Standard Errors (SE).

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira
Copepoda	97.3 (0.3)	98.5 (0.2)	73.0 (22.1)	88.1 (7.4)
Cladocera	1.1 (0.2)	0.1 (0.1)	4.3 (3.1)	3.9 (1.8)
Rotifera	1.6 (0.4)	1.4 (0.2)	22.6 (19.0)	7.9 (5.8)

Upstream sites exhibited considerably higher total zooplankton abundance (range 130,000-290,000 indiv. m^{-2}) compared to downstream sites (20,000-30,000 indiv. m^{-2}).

6.4. Discussion

The taxonomic composition reported here is comparable to that observed in the April 2000 AES report. In the 2000 survey, the second quarter report (Mwebaza-Ndawula *et al.* 2005; NARO AES Report 2000) indicated only a single species of Cladocera, *Diaphanosoma excisum*. This time round, the cladoceran species composition was much more diverse and comprised *Bosmina longirostris, Ceriodaphnia cornuta, Daphnia lumholtzi, D. excisum, Moina micrura* and *Macrothix* sp. Downstream decrease of zooplankton densities was also similar to the pattern observed in April 2000. The magnitude of the total densities observed (<5000 - 290,000 indiv. m^{-2}) is within range of those observed in April 2000 surveys (700-130,000 indiv. m^{-2}) but is well below density estimates for Lake Victoria which is the ultimate source of the River Nile water. In the 2000 AES report it was suggested that flowing water conditions probably have a major bearing on the biological mechanisms regulating zooplankton abundance as noted by Rzoska (1978). Such and other differences may be expected in comparisons of communities involving standing and running water ecosystems. Species richness decreased from 13-16 upstream to 2-7 in downstream sites. While the trend is similar to that of the 2000 AES data, these ranges appear to be wider than those observed in the 2000 surveys i.e. 2-6 recorded in the April 2000 data. The superabundance of copepods over other taxa is in consonance with observations in the AES data of April 2000.

6.5. Summary

- Species composition was dominated by rotifera while both Cladocera and copepods contributed nearly an equal number of species at most sites.
- Species richness decreased progressively from upstream to downstream sites
- Cyclopoid copepod taxa generally exhibited higher abundance estimates (up to 287,000 indiv. m^{-2}) especially in upstream sites at Kalange-Makwanzi and Buyala-Kikubamutwe.
- Upstream sites exhibited higher total zooplankton abundance (range 130,000-290,000 indiv. m^{-2}) compared to downstream sites (20,000-30,000 indiv. m^{-2}).
- In all cases, Copepoda contributed the greatest percentage of the total zooplankton (> 70%).

6.6. Conclusion and way forward

The survey reveals considerable similarity between the present data and that collected earlier by the AES project in April 2000. Some key aspects of the environment appear to have changed significantly over time. The current low water level is a case in point. This phenomenon was clearly visible during sampling with the watermark having receded as much as 10 metres in some places. Notably however, such changes in water level did not affect the location of sampling sites established during the 2000 AES surveys, which were the same points sampled in the present investigation.

The data generated here will, in due course, be compared to that to be generated in subsequent quarters in order to reveal temporal-spatial patterns of the zooplankton community constituents along the stretch of Upper Victoria Nile under study.

CHAPTER 7

7.0. The Diversity and Relative Abundances of Macro-invertebrates in the Upper Victoria Nile

7.1. Background

Aquatic macro-invertebrates mostly live in/on the bottoms of rivers, streams and lakes but some can live under roots of marginal plants. All macro-invertebrates macro-inveterbrates can be seen with naked eyes and have their own adaptations and requirements to life under water. They are good indicators of water quality due to their varying sensitivity to water pollution. Thus, diversity and abundance of macro-invertebrate types and how they frequently occur can be an indication of environmental quality of an aquatic system.

This report provides baseline information on the diversity and relative abundance of macro-invertebrates for the pre-construction period (1st quarter) of the Bujagali Hydropower Project at Dumbbell site on the Upper Victoria Nile. This study was conducted between 6th –13th April 2006. The assessment survey was conducted at three points (east, mid and west) on one upstream transverse transect (Kalange-Naminya) and three downstream transects (Buyala-Kikubamutwe, Kirindi-Matumu and Sangabwire-Lubwata/Namasagali). Similar data will be collected in the subsequent quarters and during construction and post-construction operation of the project. Results from this survey are compared with those that were obtained in April 2000 under AESNP EIA study of the second quarter.

7.2. Materials and Methods

Samples were collected from among plant roots and from benthic sediments. Sediment samples were collected in triplicate using a ponar grab of surface area 236.45 cm^2 at three points namely, west, mid and east along the transverse transects, one of which is upstream and three downstream the proposed Hydropower Dam project at Dumbbell site (Fig.2.1a). The macro-invertebrates from plant roots were collected using a 400 µm mesh net of cross-section area 1 885 cm^2. The net, mounted on a long handle, was inserted below the plant roots and moved vertically up and down several times to dislodge and collect the organisms. The samples were sieved through a washing bag of mesh size 500 µm and preserved with 70% alcohol in plastic sample bottles. In the laboratory, the macro-fauna were sorted, identified mostly to genus level (Merritt & Cummins 1997, Pennak 1989, Voshell 2002) and enumerated. Part of each sample was re-preserved in 70 % alcohol and stored in plastic vials for future reference. Results were computed as number of organisms per square meter.

7.3. Results

7.3.1. Comparison of total benthic density: April 2000 and 2006

Total benthic density was highest at Kalange-Naminya (Transect 1) during April 2000 survey whereas in this survey, density was highest at the Matumu-Kirindi (Transect 2) (Fig. 7.2). The overall areal density at the former reached a high of 14,705 ind. m^{-2} on the eastern sampling point of the transect and 11128 ind. m^{-2} on the western point. At the latter, maximal densities of 2580 and 2453 ind. m^{-2} respectively were registered at the eastern and western sampling points of the transects.

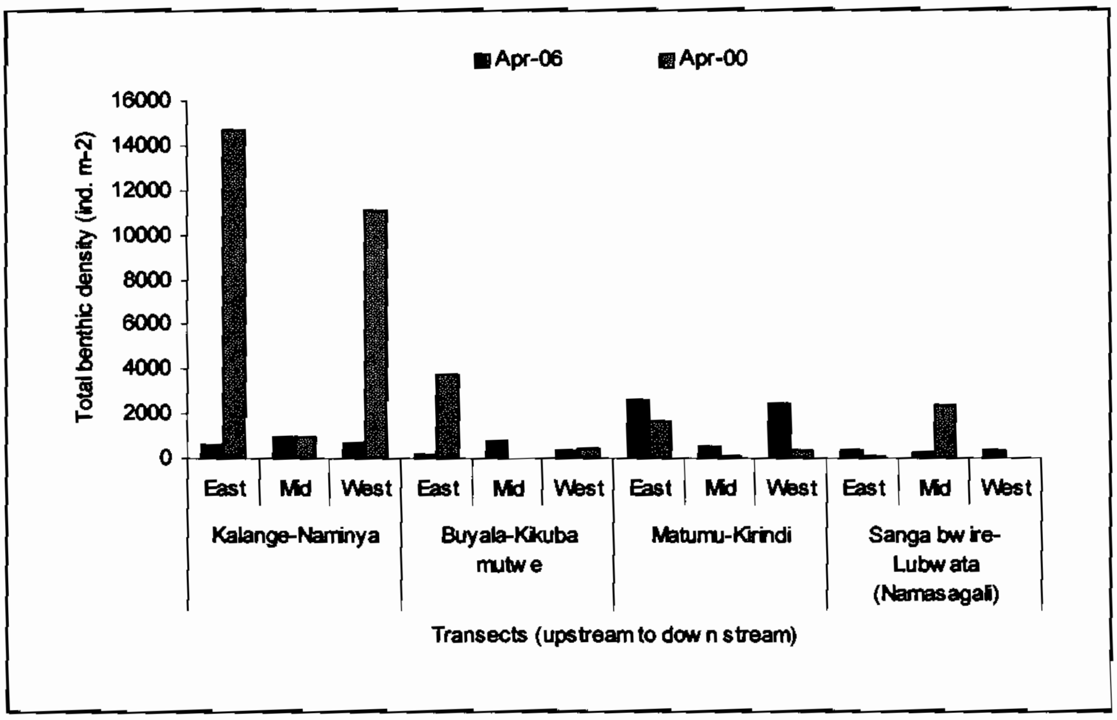


Fig. 7.2. Comparison of overall benthic macro-invertebrates density across four transects on the upper Victoria Nile during April 2000 and 2006.

7.3.2. Comparison of total macro-invertebrate density under plant roots:April 2000 and 2006

The densities of macro-invertebrates under plant roots for this survey were slightly higher than those during April 2000 survey (Fig. 7.3). Density during this survey ranged from 57 ind.m^{-2} at the mid point on Kalange-Naminya transect to 354 ind.m^{-2} at western edge of Sangabwire-Lubwata (Namasagali) transect. During the April 2000 survey, the density varied from 44 ind.m^{-2} at the eastern edge of Sangabwire-Lubwata (Namasagali) transect to 153 ind.m^{-2} at the eastern edge of Kalange-Naminya transect.

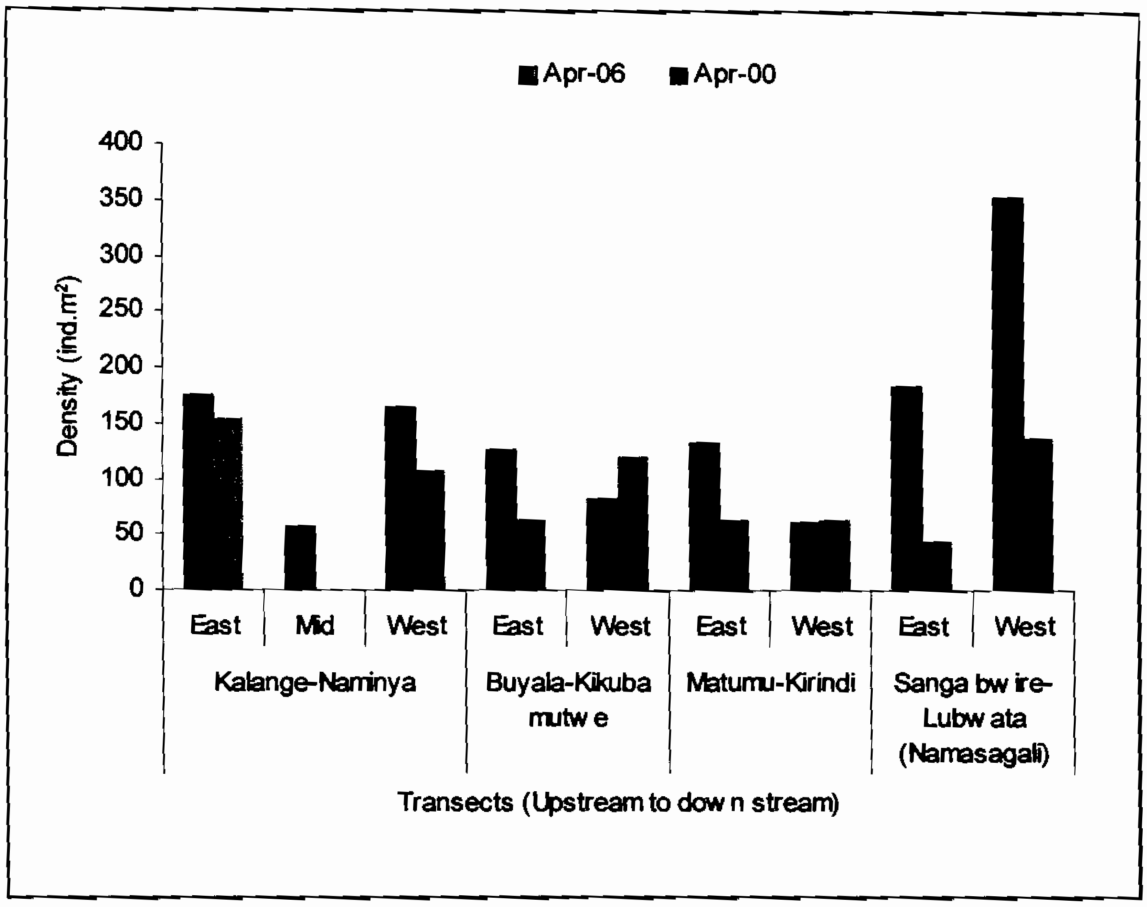


Fig. 3. Comparison of overall macro-invertebrates density under plant roots across four transects on the Upper Victoria Nile during April 2000 and 2006.

7.3.3. Comparison of macro-invertebrate density: benthic and under plant roots

Along all transects benthic macro-invertebrates density was much higher than that under plant roots (Fig. 7.4). The highest benthic density was recorded at the eastern and western sample points of Matumu-Kirindi transect, up to 2580 and 2453 indi. m^{-2}, respectively. Along the Sangabwire-Lubwata Namasagali transect, density ranged between 240 at the mid point and 381 indi. m^{-2} at the eastern point (Fig. 7.4). For densities under plant roots, there were no samples obtained at mid points except on Kalenge-Naminya transect, where there was a small island, which had plants.

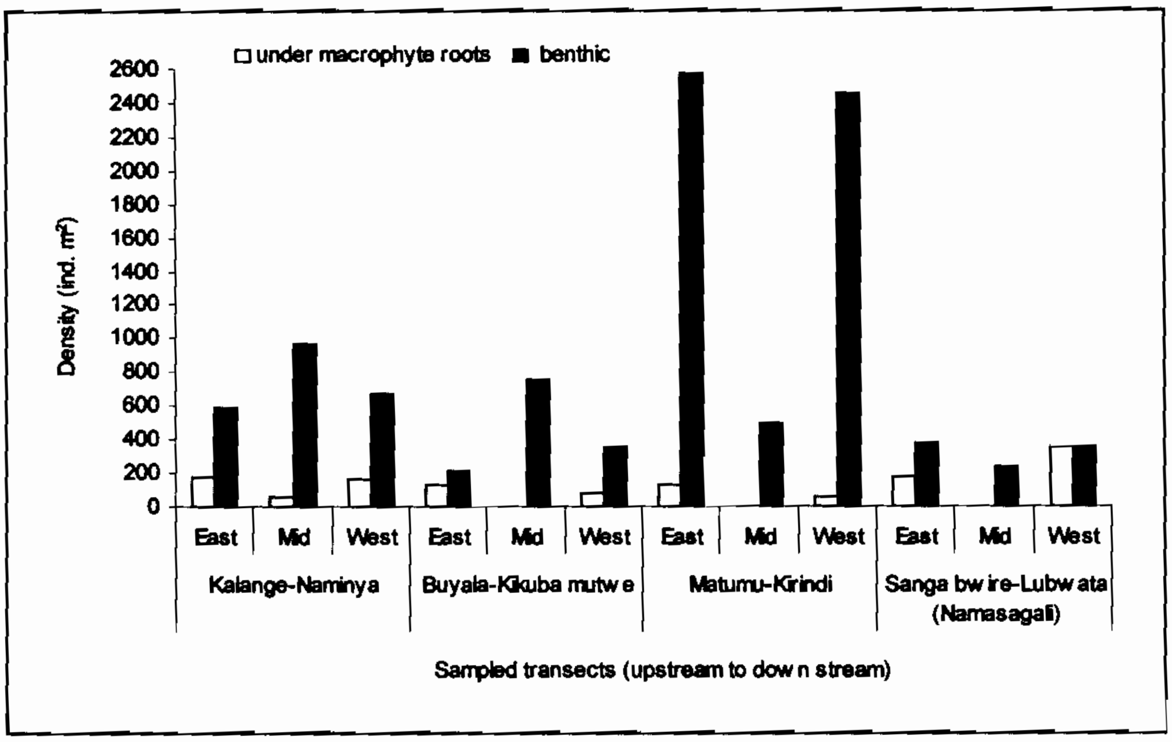


Fig. 7.4. Comparison of benthic macro-invertebrates density and of macro-invertebrates under roots of marginal plants along four transects, April 2006

7.4. Relative taxa densities under plant roots

Along the most downstream transect, Sangabwire-Lubwata/Namasagali, *Caridina nilotica* was the most dominant taxon comprising 69% (244 ind. m^{-2}) and 82 % (150 ind. m^{-2}) of density at western and eastern points of the transect, respectively (Fig. 5). The other taxa at the western edge of the transect were: Ephemeroptera (9%), Bivalvia (9%), Chironomidae (6%), Gastropoda (3%), Odonata (3%), Coleoptera (2%) and Hydracarina (2%); and at the eastern point, they were: Ephemeroptera (6%), Chironomidae (6%), and Hydracarina (3%). During April 2000 survey, *C. nilotica* was as important as during this survey, contributing 64% (28 ind. m^{-2}) and 83% (114 ind. m^{-2}) at the eastern and western edges of the transects, respectively (AESNP report, 2nd quarter 2000). Taxa like Ephemeroptera and Chironomidae contributed 17% and 4% respectively at the western edge of the transect during April 2000 survey. Hydracarina was the only other taxon that was recorded at the eastern edge during second quarter April 2000 survey.

At the eastern point on Matumu-Kirindi transect, the bivalves dominated the density by 56% (74 ind. m^{-2}), followed by gastropods 36% (48 ind. m^{-2}), *Caridina nilotica* 16% (21 ind. m^{-2}), ephemeropterans 14% (19 ind. m^{-2}), odonates 8% (11 ind.m^{-2}) and hemipterans 3% (4 ind.m^{-2}) (Fig. 7.3). At the western point on Matumu-Kirindi transect, *C. nilotica* contributed the highest density 45 % (28 ind. m^{-2}), then followed by Bivalvia 19% (12 ind. m^{-2}), Ephemeroptera 15 % (9 ind. m^{-2}) and Odonata 11% (7 ind. m^{-2}) and Gastropoda 8% (12 ind. m^{-2}). During the April 2000 survey, five taxa were encountered as follows: ephemeropterans 35% (22 ind. m^{-2}), Gastropds 10% (6 ind. m^{-2}), odonates 18 % (11 ind. m^{-2}), tricopterans 10% (6 ind. m^{-2}) and Hydracarina 27% (17 ind. m^{-2}) at the western edge. On the eastern edge too, 5 taxa were recorded which included ephemeropterans 37% (23 ind. m^{-2}), chironomides 37% (23 ind. m^{-2}) Gastropds 10% (6 ind. m^{-2}), tricopterans 10% (6 ind. m^{-2}) and plecopterans 10% (6 ind. m^{-2}) at the western edge.

At the Buyala-Kikubamutwe western point, Ephemeroptera contributed 52% (44 ind. m^{-2}) the highest density followed by Bilvalvia 13% (11ind. m^{-2}), *C. nilotica* 11 % (9 ind. m^{-2}), Gastropoda 11% (9 ind. m^{-2}), Odonata 8% (7 ind. m^{-2}) and Chironomidae 6% (5 ind. m^{-2}) (Fig. 7.4). At the eastern point on Buyala-Kikubamutwe transect, *C. nilotica* 49 % (62 ind. m^{-2}) was the most dominant, then followed by Ephemeroptera 29 % (37 ind. m^{-2}), Bilvalvia 11% (14 ind. m^{-2}), Gastropoda 11% (14 ind. m^{-2}) and Hemiptera 9% (11 ind. m^{-2}) (Fig 7.5). There were three taxa recorded at the western edge of the transect during April 2000 survey namely: Gastropoda 5 % (6 ind. m^{-2}), Bivalvia 90% (108 ind. m^{-2}) and chironomidae 5% (6 ind. m^{-2}). During the same survey, four taxa were encountered, including Gastropoda 13% (8 ind. m^{-2}), Bivalvia 64% (40 ind. m^{-2}), Hemiptera 18 % (11 ind. m^{-2}) and Chironomidae 3% (2 ind. m^{-2}).

At the Kalange-Naminya western point, Ephemeroptera contributed the most by 34% (55 ind. m^{-2}), followed by Chironomidae 13% (21 ind. m^{-2}), *C. nilotica* 13% (21 ind. m^{-2}), Bilvalvia 13% (21 ind. m^{-2}), Simulium sp. 13% (21 ind. m^{-2}), Gastropoda 7% (12 ind. m^{-2}), Hemiptera 7% (12 ind. m^{-2}) and Odonata 4% (7 ind. m^{-2}). At the eastern point on the same transect, Ephemeroptera 27% (48 ind. m^{-2}) was the most dominant, then followed by Gastropoda 21 % (37 ind. m^{-2}), Odonata 16 % (28 ind. m-2), Chironomidae 15% (27 ind. m^{-2}), *C. nilotica* 7% (12 ind. m^{-2}), Hydracarina 8% (14 ind. m^{-2}) and Hemipera 2% (4 ind. m^{-2}). It was only on this transect that the mid point was sampled for macro invertebrates under plant roots, which consisted of Ephemeroptera 72% (41 ind. m^{-2}), Coleoptera 4% (2 ind. m^{-2}) and Chironomidae 16% (9 ind. m^{-2}) (Fig. 7.5). Unlike in the current survey, during April 2000 survey, Nematodes were recorded at both the eastern and western edges of the transect, contributing 60% (91 ind. m^{-2}) and 6% (6 ind. m^{-2}) of total density respectively. Apart from Nematodes, three other taxa were recorded at the eastern edge, and these included gastropods 30% (46 ind. m^{-2}), ephemeropteran 7% (11 ind. m^{-2}) and hemipterans 4% (6 ind. m^{-2}). Then on the western edge, six other taxa were encountered and these were: gastropods 21% (23 ind. m^{-2}), ephemeropterans 21% (23 ind. m^{-2}) and hemipterans 16% (17 ind. m^{-2}), chironomids 10% (11 ind. m^{-2}), odonates 16% (17 ind. m^{-2}) and Hydracarina 10 % (11 ind. m^{-2}).

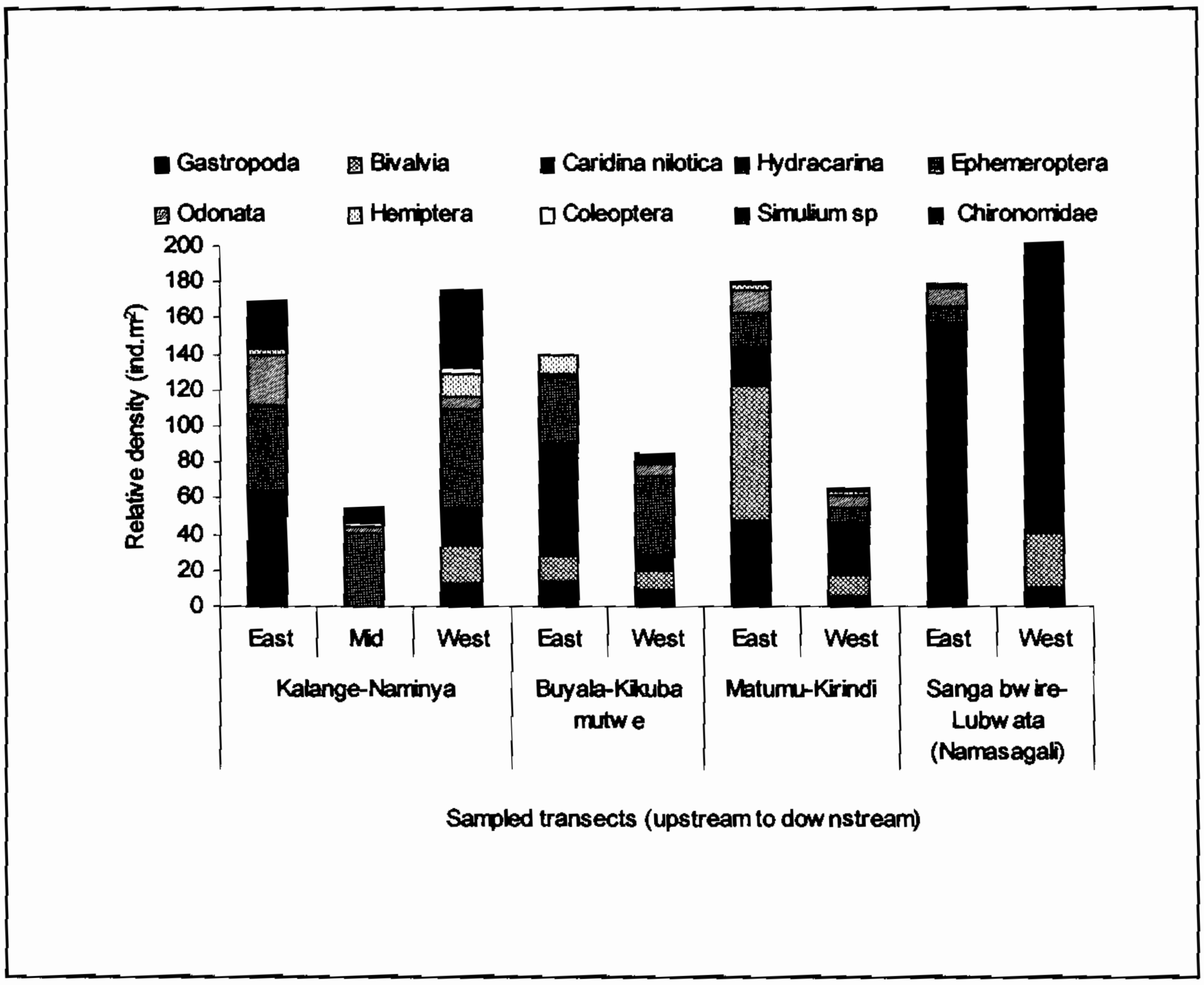


Fig. 7.5. Relative density of major taxa of macro-invertebrate under roots of plants along four sampling transects on Upper Victoria Nile, April 2006.

7.5. Relative taxa densities of benthic macro-invertebrates

Along Sangabwire-Lubwata Namasagali transect, at western and eastern points respectively, only one taxon, Chironomidae at densities of 310 and 296 ind. m^{-2} was encountered (Fig. 7.6). However, at the mid of the transect, three taxa were found namely Chironomidae 47% (113 ind. m^{-2}), Bivalvia 18% (42 ind. m^{-2}) and Ephemeroptera 6% (14 ind. m^{-2}). During the April 2000 survey, two taxa, Nematoda 63% (68 ind. m^{-2}) and Chironomidae 37% (41 ind. m^{-2}) were recorded at the eastern edge. At the western edge too in this survey, two taxa, Bivalvia 67 % (27ind. m^{-2}) and Chironomidae 33% (14 ind. m^{-2}) were encountered, and at the mid point, six taxa groups were encountered dominated by Bivalves 82% (1972 ind. m^{-2}). The other taxa included Ephemeroptera, Trichoptera, Odonata, Nematoda and Chironomidea.

At the eastern point on Matumu-Kirindi transect, Chironomidae dominated the density by 61% (1579 ind. m^{-2}) followed by Bivalvia 16% (409 ind. m^{-2}), Gastropoda 10% (268 ind. m^{-2}), *Ostracoda* 7% (169 ind. m^{-2}) and Ceratopogonidea 3% (70 ind.m^{-2}). At the western point on this transect, Chironomidae still contributed *the* most by 61% (1508 ind. m^{-2}) followed by Bivalvia 28% (677 ind. m^{-2}), Gastropoda 7% (169 ind. m^{-2}) and Ceratopogonidea 2% (42 ind.m^{-2}). The mid point on the transect registered very low benthic density that comprised of three taxa: Chironomidae 31% (155 ind. m^{-2}), Ephemeroptera 26% (127 ind. m^{-2}) and Bivalvia 17% (85 ind. m^{-2}). During the April 2000 survey, 5 taxa group were recorded at both the western and eastern edge of the transect. At the eastern edge, these were Chironomidae 74% (1197 ind. m^{-2}), Ephemeroptera 24% (380 ind. m^{-2}), Tricoptera 1% (14 ind. m^{-2}), Bivalvia 1% (14 ind. m^{-2}) and Gastropoda 1% (14 ind. m^{-2}). At the western edge, Chironomidae 52% (190 ind. m^{-2}), Bivalvia 30% (108 ind. m^{-2}) Odonata 11% (41 ind. m^{-2}), Tricoptera 4% (14 ind. m^{-2}), and Nematoda 4% (14 ind. m^{-2}) were recovered. At the mid, two taxa, Chironomidae 57% (54 ind. m^{-2} and Tricoptera 43% (41 ind. m^{-2}) were recorded.

At the Buyala-Kikubamutwe western point, three taxa were encountered namely: Ephemeroptera 56% (197 ind. m^{-2}), Gastropoda 16% (56 ind. m^{-2}) and Chironomidae 16% (56 ind. m^{-2}) Fig. 6. At the mid point of the transect, three taxa too were encountered as follows: Bivalvia 35% (268 ind. m^{-2}), Gastropoda 37% (282 ind. m^{-2}) and Chironomidae 26 % (197 ind. m^{-2}). At the eastern point on the transect, Bilvalvia was 20% (42 ind. m^{-2}). The other two taxa were Chironomidae and Gastropoda each contributing 33 % (70 ind. m^{-2}). During April 2000 survey, Bivalvia was the most dominant taxon at both eastern and western edges of the transect by 70% (2643 ind. m^{-2}), and 58% (258 ind. m^{-2}), respectively. At the eastern edge during the same survey, five other taxa were recorded as follows: Gastropoda 21% (784 ind. m^{-2}), Ephemeroptera 2% (81ind. m^{-2}), Tricoptera 1 % (45ind. m^{-2}), Odonata <1% (14 ind. m^{-2}), Chironomidae 5% (204 ind. m^{-2}) and Nematoda <1% (23 ind. m^{-2}). The mid point registered no benthos during this survey.

At the Kalange-Naminya eastern point, three taxa were encountered, namely Chironomidae 62% (367 ind. m^{-2}), Bivalvia 29% (169 ind. m^{-2}) and Ceratopogonidea 2% (14 ind. m^{-2}). At the mid point, three taxa were encountered as follows: Chironomidae 52% (508 ind. m^{-2}), Bivalvia 25% (240 ind. m^{-2}) and Ephemeroptera 10% (99 ind. m^{-2}). At the western point, only two taxa were encountered, Gastropoda 27% (183 ind. m^{-2}) and Bivalvia 62 % (423 ind. m^{-2}). During April 2000 survey, Gastropoda was the most dominant taxon at both eastern and western edges of the transect by 53 % (7768ind. m^{-2}), and 89% (9862 ind. m^{-2}), respectively. At the eastern edge during the same survey, six other taxa were recorded as follows: Ephemeroptera 23% (3414 ind. m^{-2}), Tricoptera 1% (45ind. m^{-2}), Bivalvia 3% (462ind. m^{-2}), Odonata <1 % (14 ind. m^{-2}), Chironomidae 5% (204 ind. m^{-2}) and Nematoda <1% (23 ind. m^{-2}). Apart from gastropods, five other taxa were encountered namely: Ephemeroptera 2% (299 ind. m^{-2}), Tricoptera <1% (14 ind. m^{-2}), Bivalvia<1% (54 ind. m^{-2}), Chironomidae 4% (490 ind. m^{-2}) and Nematoda 3 % (408 ind. m^{-2}).

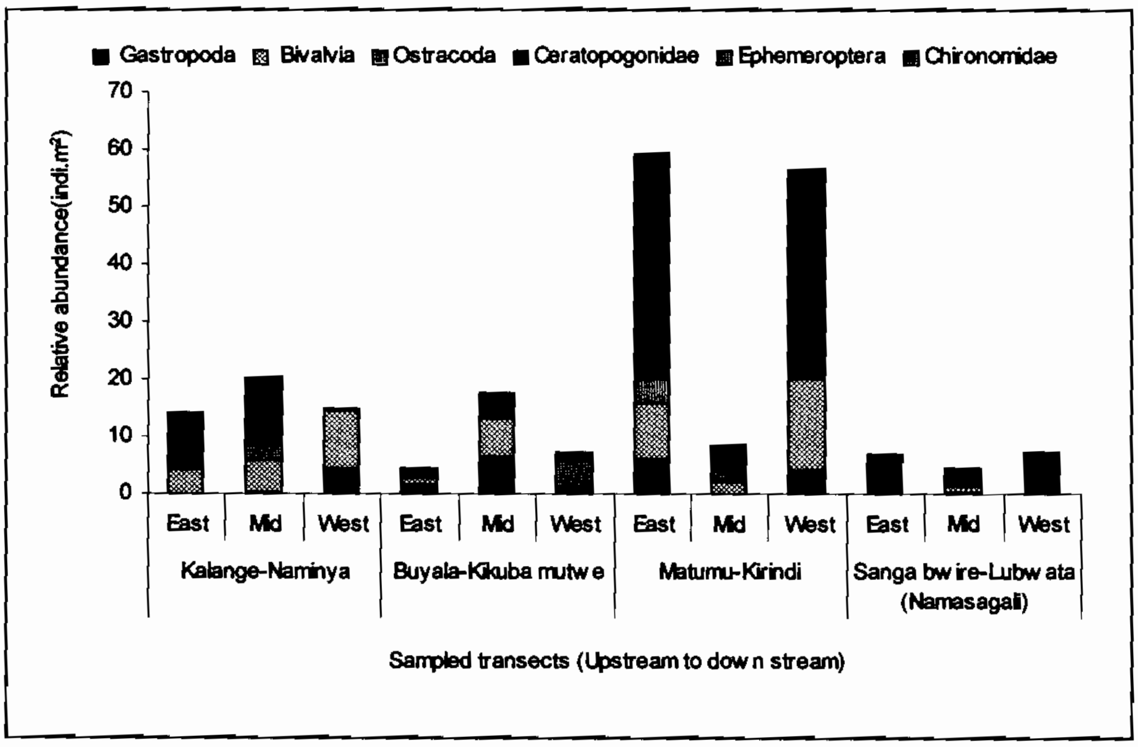


Fig. 7.6. Relative taxa composition and abundance of benthic macro-invertebrates at the eastern, mid and western sampling points on four transects across the upper River Victoria Nile, April 2006

7.6. Discussion

One group of organisms especially sensitive to water pollution are the combined insect Orders of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), abbreviated EPT. High numbers (at least 100 indi. m^{-2}) of these organisms in a river represent good water quality. Their absence or just occasional occurrence may indicate a pollution problem. A macro-invertebrate community dominated by organisms more tolerant of pollution, such as aquatic worms and midges, usually indicates a problem.

CHAPTER 8

8.0. Fish species Composition and Relative Abundance

8.1. Background

Construction of the proposed Bujagali Hydroelectric dam at Dumbbell Island on the River Nile is likely to cause changes in the river water regimes both upstream and downstream. This may affect fish habitats and thus composition and abundance of fish populations above and below the dam. Many fish species presently occurring in this river are suited to particular types of habitats that may be altered by the presence of the dam. Water quality characteristics during construction are likely to be altered and could also affect fish distribution along the river. Considering that fish provide the cheapest source of animal protein and income to the riparian human populations along this river any change in the fish populations could affect the livelihood of these people. It is therefore necessary to monitor changes in fish composition and abundance to mitigate dam construction effects. The objectives of this study therefore were to:

a) Determine fish species composition at selected transects upstream and downstream of the proposed dam site.
b) Determine changes in their size distribution over time at those sites.
c) Assess the relative abundance of the species.
d) Monitor the above parameters during and after dam construction.

This part of the report gives the present fish species composition, distribution and their relative abundance along transects upstream and downstream of Dumbbell Island and compares the results with the April 2000 study. Monitoring the above parameters is expected to be done prior to, during and after construction in order to determine changes in fish population as influenced by both the construction and the presence of the dam.

8.2. Materials and Methods

Three fleets of gill-nets comprising pieces of mesh sizes 1" to 5.5" in 0.5" increments, and 6 to 8 in 1" increments were set overnight twice at each of the four transect stations between 6th – 13th April 2006. A similar procedure was used during the April 2000 survey. At each station, fleets were set so as to cover a broad range of habitat conditions i.e. of different bank features such as vegetation or rock, adjoining bays, mid-channel, and off islands. Locality names were noted.

The nets were set between 1800hr to 1900hr, and removed between 06.00h and 07.00h the following day. Each block of nets was separated and handled according to fishing grounds.

Experimental catch and biometric data on large sized fish species were taken on spot while the smaller sized ones were preserved for laboratory examination. Fish were sorted according to mesh size, identified and separated into species

Measurements (weight in grams, length as total length in centimetres) and other biometric indices (sex, gonad condition, degree of stomach fullness and fat content) were recorded. Gonad maturity state was based on I to VII - scale according to the method of (Bagenal and Braum, 1978). Stomach fullness and fat content were assessed by eye as empty, ¼, ½, ¾ and full.

Stomach contents of small fishes and the tilapiines and ripe ovaries - states V and VI were preserved respectively in a mixture of 5-10% formalin and 50% ethanol for laboratory analyses. Due to their growth form, the length (in centimeters) of fish was measured either as Total Length (TL), Forkal Length (FL), or Standard Length (SL).

8.3. Results

8.3.1. Catch composition

A total of 18 fish species were recorded at all stations along the river (Table 8.1). 11 species were recorded at Buyala, 10 at Kalange, seven at Namasagali, and six at Kirindi. *L. niloticus* and the Haplochromines were caught at all stations sampled. Although experimental nets missed *Rastrineobola argentea*, the species was observed at Buyala from the local fisher's catches.

In terms of numbers, catches were dominated by the haplochromines. *M. kannume* and *L. niloticus* were second and third respectively in importance (Fig. 8.1). By weight, *M. kannume* became the dominant fish species followed by *L. niloticus* and then the haplochromines (Fig. 8.2).

8.3.2. Catch rates / biomass estimates

As a measure of standing biomass, catch rates (i.e. catch per net per night) was used as indicator of relative abundance of fish species from the stations under survey. To analyze for catch per net, gillnets were grouped into three size categories, small (1 to 2½ inches stretched mesh), medium (3 to 4½) and large (5 to 8 inches). There was no order of biomass with distance from either lake. Highest biomass was recorded at Buyala and lowest at Kirindi. The overall catch per net both by numbers and weight decreased with the size category of net (Fig. 8.3). Total catch rates of different fish species from the four stations during the current and a similar quarter in 2000 are given in Table 8.2. Highest biomass in the river comprised of the haplochromines with a catch rate of 188.7g per net. *M. kannume* with a mean catch rate of 165.7.2g per net was second. Other fish species showing high rates in order of importance were *L. niloticus* (70.4g), *Tilapai zillii* (30.4g) and *Barbus altianalis* (29.3g). All these are species that grow to large adult sizes (keystone species) and therefore form the basis of the artisanal fishery along this river. With the exception of the haplochromines which dominated the catch, catches of all species from the April 2006 survey were lower compared to a similar period in 2000.

8.3.3. Length frequency Distribution

Size distribution of *Lates niloticus* caught during the survey (Fig. 8.4) ranged from 8 to 37cm TL. All the *Lates* specimens caught were immature with mean length ranging from 18.3 cm in Buyala to 21.6cm TL in Kirindi. *M. kannume* ranged in size from14 to 64cm FL. Fishes of the size range 21 to 25 cm FL dominated the population of this species in the river (Fig. 8.5). The overall mean length was calculated at 19 cm TL. The largest *Mormyrus* was at 64 cm FL and was recorded at Buyala. All *R, argentea* caught in the artisanal fishery at Buyala were immature with an average length of 19 mm SL.

8.4. Discussion

Fish species caught in the Upper Victoria Nile are typical Victorian (inshore) and Kyoga fauna. At Kirindi, the middle station yielded *Xystichromis bayoni*, a typical Upper Victorian haplochromine. Using catch rates (catch per net), one can arrive at an indication of the biomass of different fish species found in the river. These rates will over time be the basis of comparative assessment of stocks at different times and from different transects. Gillnetting revealed low catch rates compared to a similar period in 2000. The order of importance of fish species also shifted in favour of the haplochromines in the April 2006 survey. This is in agreement with the current trends in the two lakes terminal to the upper Victoria Nile. In these lakes a recovery of haplochromines has been observed (IFMP reports 2005, NAFIRRI Report 2006). There was also a noticeable increase in the biomass of *Oreochromis variabilis* a species native to the two lakes, (Lake Victoria and Lake Kyoga) whose numbers had been greatly reduced in these waters. *O. niloticus* performed poorly compared to the previous April 2000 survey. Even among the artisanal catches this species was prominent in Kalange the nearest station to Lake Victoria and at Namasagali, nearest to L. Kyoga. Low catches of *O. niloticus* are common during breeding periods of the species as mobility and thus access to gillnets is reduced due to breeding activities.

8.5. Summary

- 18 fish species were recorded from experimental nets along the river, between Kalange and Namasagali.
- Highest species diversity was observed from Namasagali consisting mainly of anadromous fish species from Lake Kyoga.
- All keystone species identified during the previous survey were present. Commercially important fish species in the river *M. kannume, B. altianalis,* and *L. niloticus* were encountered at all stations along the river.
- Gillnets set in shallow waters very close to the shores recovered fish species that grow to a small adult size and juveniles of the large species while the large adults tended to be found in the deeper waters in the middle of the river.

- Small sized fishes dominated catches with the highest rates registered by the haplochromines.

8.6. Conclusion

All keystone fish species expected in the river were recorded. Poorer fish catches were realized compared to a similar season in 2000. This could have probably been due to less amount of movement due to breeding activities. This time round, the perennial problem of net loss in the river was minimal. It occurred only at Namasagali where on the first day of setting, a whole fleet was washed away by the strong current.

Table 8.1. Fish species recorded at the four sampling stations on the Upper Victoria Nile April 2006

Family	Species	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Kirindi to Matumu	Transect 4 Downstream Namasagali to Bunyamira	All Transects April 2000
Bagridae	*Bagrus docmak*			p		p
Centropomidae	*Lates niloticus*	p	p	p	p	p
Characidae	*Brycinus jacksonii*		p			p
	B. sadleri	p				p
Cichlidae	*Oreochromis niloticus*	p	p			p
	O. leucostictus	p	p			p
	O. variabilis	p	p			p
	Tilapia zillii	p	p		p	p
	Haplochromines	p	p	p	p	p
Cyprinidae	*Barbus altianalis*	p	p	p		p
	B. paludinosus		p			p
	Labeo victorianus			p		p
	Rastrineobola argentea					p
Mochokidae	*Synodontis afrofischeri*	p				p
	S. victoriae				p	p
Mormyridae	*Marcusenius grahami*					p
	Mormyrus kannume	p	p	p		p
	M. macrocephalus					p
	Gnathonemus victoriae				p	p
	G. longibarbis				p	p
Schilbeidae	*Shilbe intermedius*					p

(p = present)

Table 8.2. Catch per net per night (g) of fish species from experimental gillnets during the 1st quarter (April 2006) at the four transects along River Nile.

Species	Transect 1 Upstream Kalange to Makwanzi		Transect 2 Downstream Buyala to Kikubamutwe		Transect 3 Downstream Kirindi to Matumu		Transect 4 Downstream Namasagali to Bunyamira		All Transects April	
	2000	2006	2000	2006	2000	2006	2000	2006	2000	2006
Bagrus docmak	0	0	19.1	0	131.0	11.2	0	0	37.5	3.5
Lates niloticus	39.9	20.6	48.7	141.5	184.2	12.4	86.6	180.3	89.9	70.4
Brycinus jacksonii	1.6	0	0	3.3	0	0	0	0	0.4	1.0
B. sadleri	0	0.6	0	Nil	0	0	14.3	0	3.6	0.2
Oreochromis niloticus	0	2.4	75.7	5.9	0	0	47.8	0	30.9	2.5
O. leucostictus	29.4	3.7	0	7.6	0	0	1.1	0	7.6	2.8
O. variabilis	33.8	33.5	0	11.6	0	0	0	0	8.5	13.5
Tilapia zillii	0	6.9	0	81.9	0	0	40.5	38.1	10.1	30.4
Haplochromines	7.3	303.9	17.1	284.9	7.7	7.7	33.9	98.0	16.5	188.7
Clarias gariepinus	0	0	0	12.0	0	0	0	0	0	3.6
Barbus altianalis	0	25.2	213.9	63.9	297.1	8.5	7.7	0	129.7	29.3
B. paludinosus	0	0	0	0.5	0	0	0	0	0	0.2
Labeo victorianus	0	0	0	0	13.6	19.3	4.2	0	4.5	5.8
Protopterus aethiopicus	27.9	0	0	0	0	0	0	0	7.0	0
Synodontis afrofischeri	0	0	0	0	0	0	135.9	153.5	34.0	18.6
S. victoriae	7.1	0	0	0	0	0	31.1	20.5	9.6	2.1
Marcusenius grahami	0	0	0	0	4.8	0	9.2	0	3.5	0
Mormyrus kannume	239.4	144.1	205.7	284.3	4.9.5	124.1	46.2	0	225.2	165.7
M. macrocephalus	0	0	0	0	0	0	20.5	0	5.1	0
Gnathonemus victoriae	0	0	0	0	0	0	1.6	151.3	0.4	15.1
G. longibarbis	0	0	0	0	0	0	2.8	18.5	0.7	1.9
Shilbe intermedius	0	0	0	0	0	0	23.5	0	5.9	0

NB: Localities associated with Transect 1 upstream include: Kikonko, Kunjaba, Makwanzi Is, Transect 2 downstream include: Naminya, Kisadha, Ofwono, Zaire, Mugalya, Kisoga, Transect 3 downstream include: Matumu, Kisoga A,B,C, Damba, Transect 4 downstream include: Kasanga, Kibuye, Sajjabi

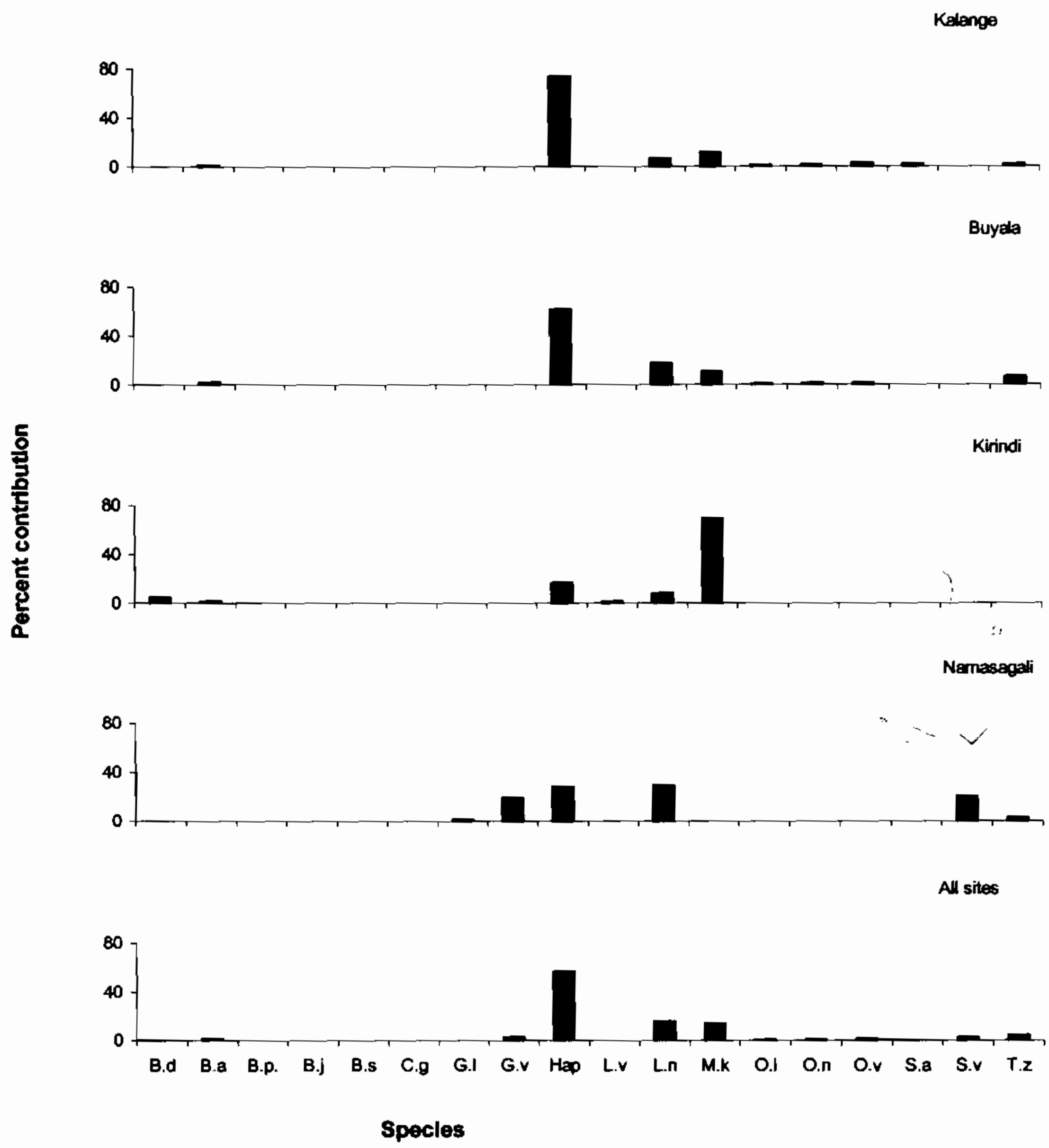


Figure 8.1 Relative abundance (numbers) of fish species caught in gill nets in April 06 along the Nile

B.j	*Brycinus jacksonii*	G.l	*Gnathonemus longiba*	O.n	*Oreochromis niloticus*
B.s	*Brycinus sadleri*	G.v	*Gnathonemus victoria*	O.l	*Oreochromis leucostictus*
B.a	*Barbus altianalis*	Haps	*Haplochromines*	O.v	*Oreochromis variabilis*
B.p	*Barbus palludinosus*	L.v	*Labeo victorianus*	S.a	*Synodontis afrofisheri*
B.d	*Bargrus docmac*	L.n	*Lates niloticus*	S.v	*Synodontis victoriae*
C.g	*Clarias gariepinus*	M.k	*Mormyrus kannume*	T.z	*Tilapia zillii*

Table 8.3. List of fish and their common names (English and Local) found during the surveys of the River Nile.

Scientific Name	Common English name	Local name
Bagrus docmac	Cat fish	Semutundu
Barbus altianalis	Barbel	Kisinja
Labeo victorianus		Ningu
Brycinus sadleri		Nsoga
Gnathonemus longibarbis		Kisoma
Gnathonemus victoriae		Kisoma / Bobo
Haplochromines		Nkejje
Labeo victorianus		Ningu
Lates niloticus	Nile perch	Mputa
Mormyrus kannume	Elephant snout fish	Kasulubana
Oreochromis leucostictus	Tilapia	Ngege
Oreochromis niloticus	Tilapia	Ngege
Oreochromis variabilis	Tilapia	Mbiru.
Synodontis afrofischeri	Catfish	Nkolongo
Synodontis victoriae	Catfish	Nkolongo
Tilapia zillii		Ngege

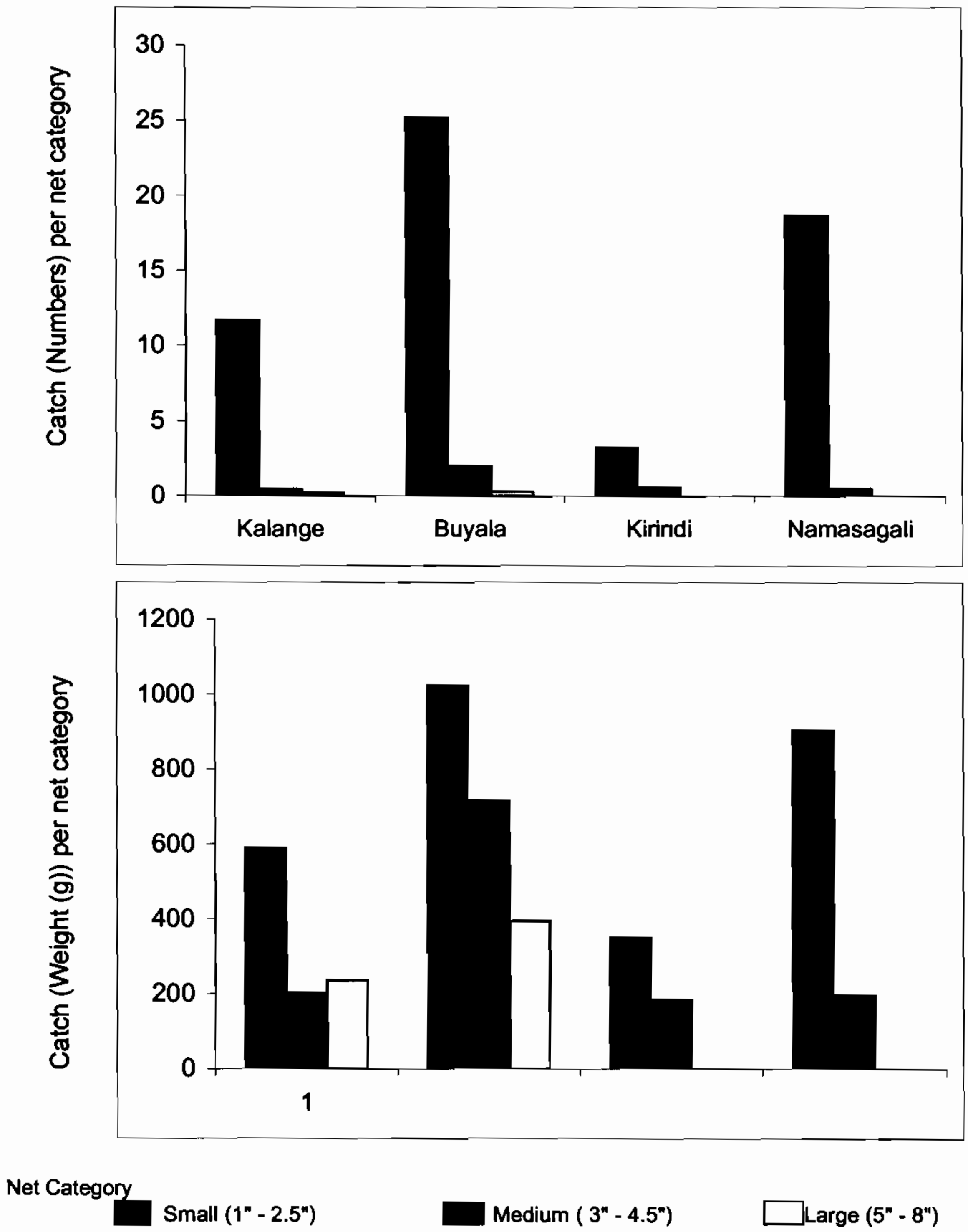


Figure 8.3 Mean catch per net category from sampled stations along River Nile - April 2006

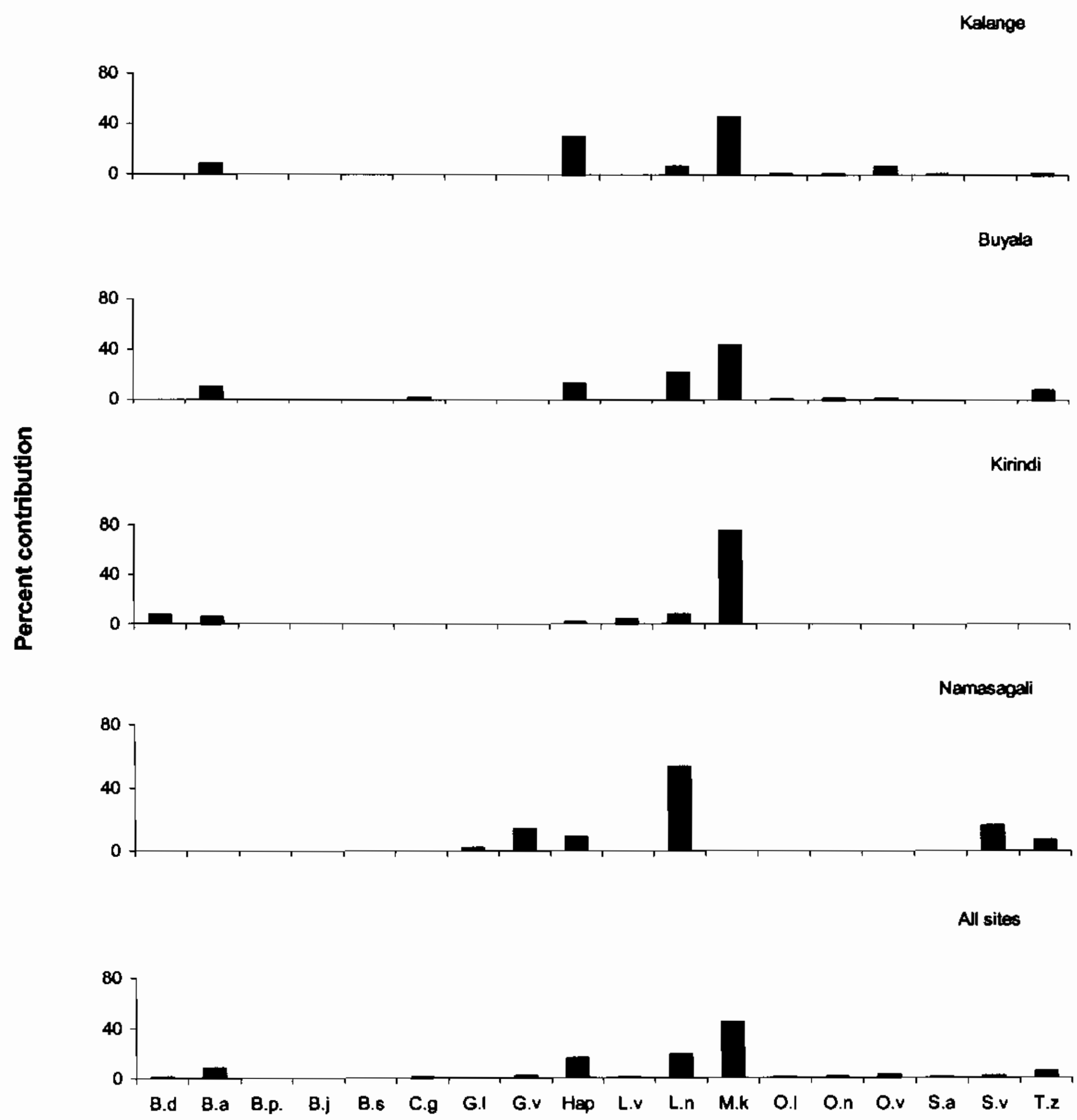


Figure 8.2 Relative abundance (weight) of fish species caught in gill nets in April 06 along the Nile

B.j	*Brycinus jacksonii*	G.l	*Gnathonemus longiba*	O.n	*Oreochromis niloticus*
B.s	*Brycinus sadleri*	G.v	*Gnathonemus victoria*	O.l	*Oreochromis leucostictus*
B.a	*Barbus altianalis*	Haps	*Haplochromines*	O.v	*Oreochromis variabilis*
B.p	*Barbus palludinosus*	L.v	*Labeo victorianus*	S.a	*Synodontis afrofisheri*
B.d	*Bargrus docmac*	L.n	*Lates niloticus*	S.v	*Synodontis victoriae*
C.g	*Clarias gariepinus*	M.k	*Mormyrus kannume*	T.z	*Tilapia zillii*

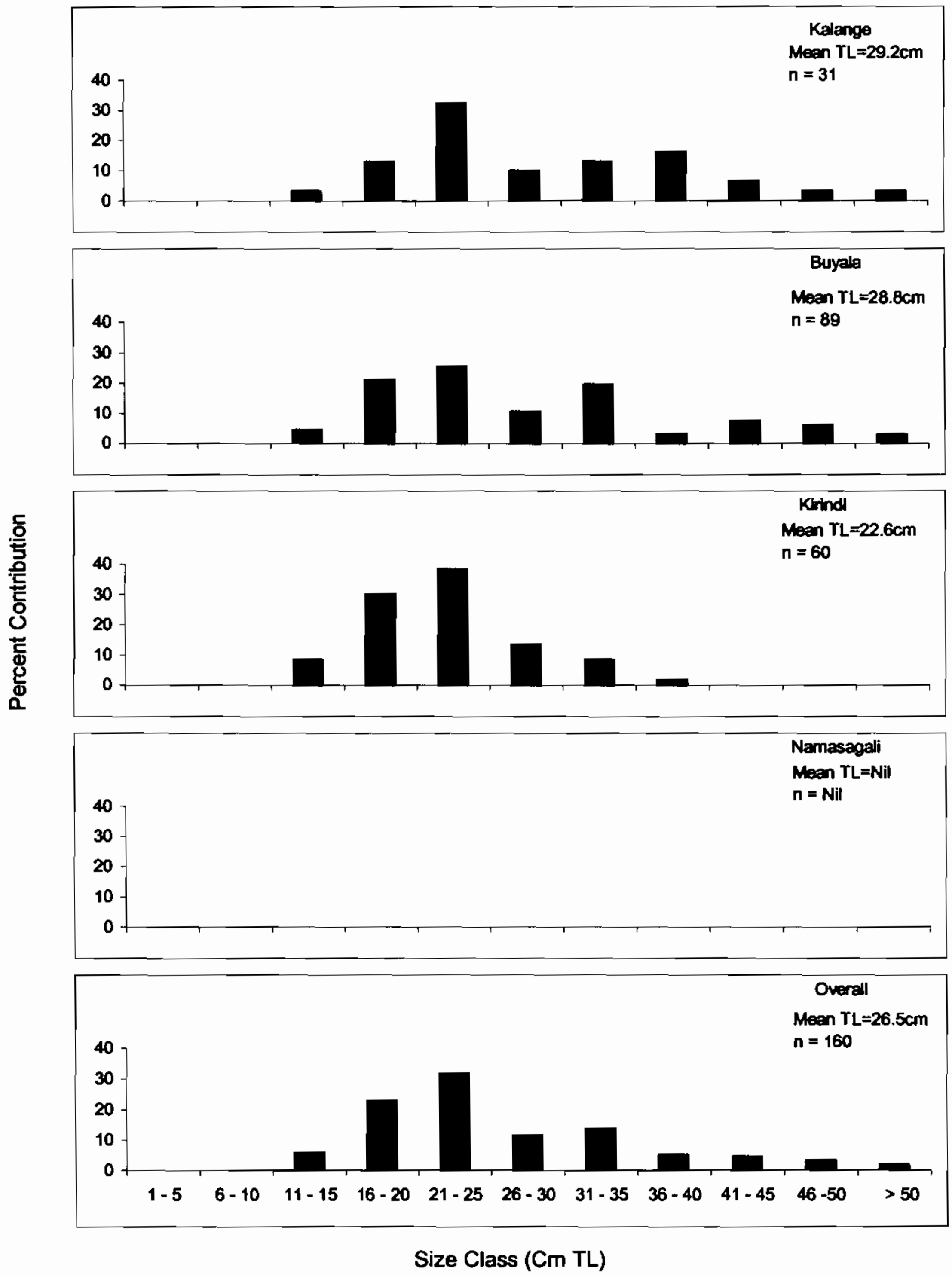


Figure 8.5 Size distribution of *Mormyrus kannume* caught in experimental gillnets at sampled stations along the Upper Victoria Nile April 2006

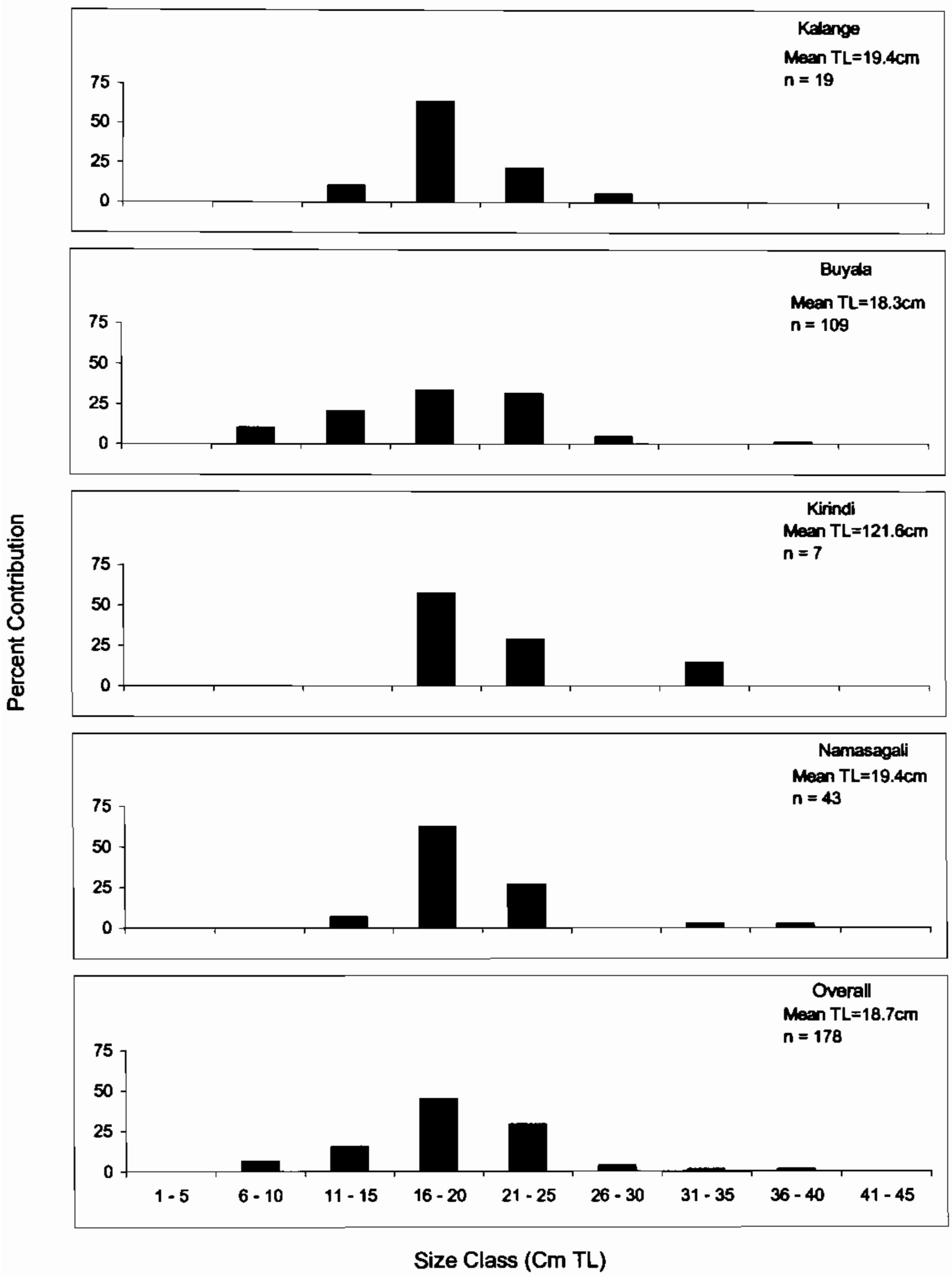


Figure 8.4 Size distribution of *Lates niloticus* caught in experimental gillnets at sampled stations along the Upper Victoria Nile April 2006

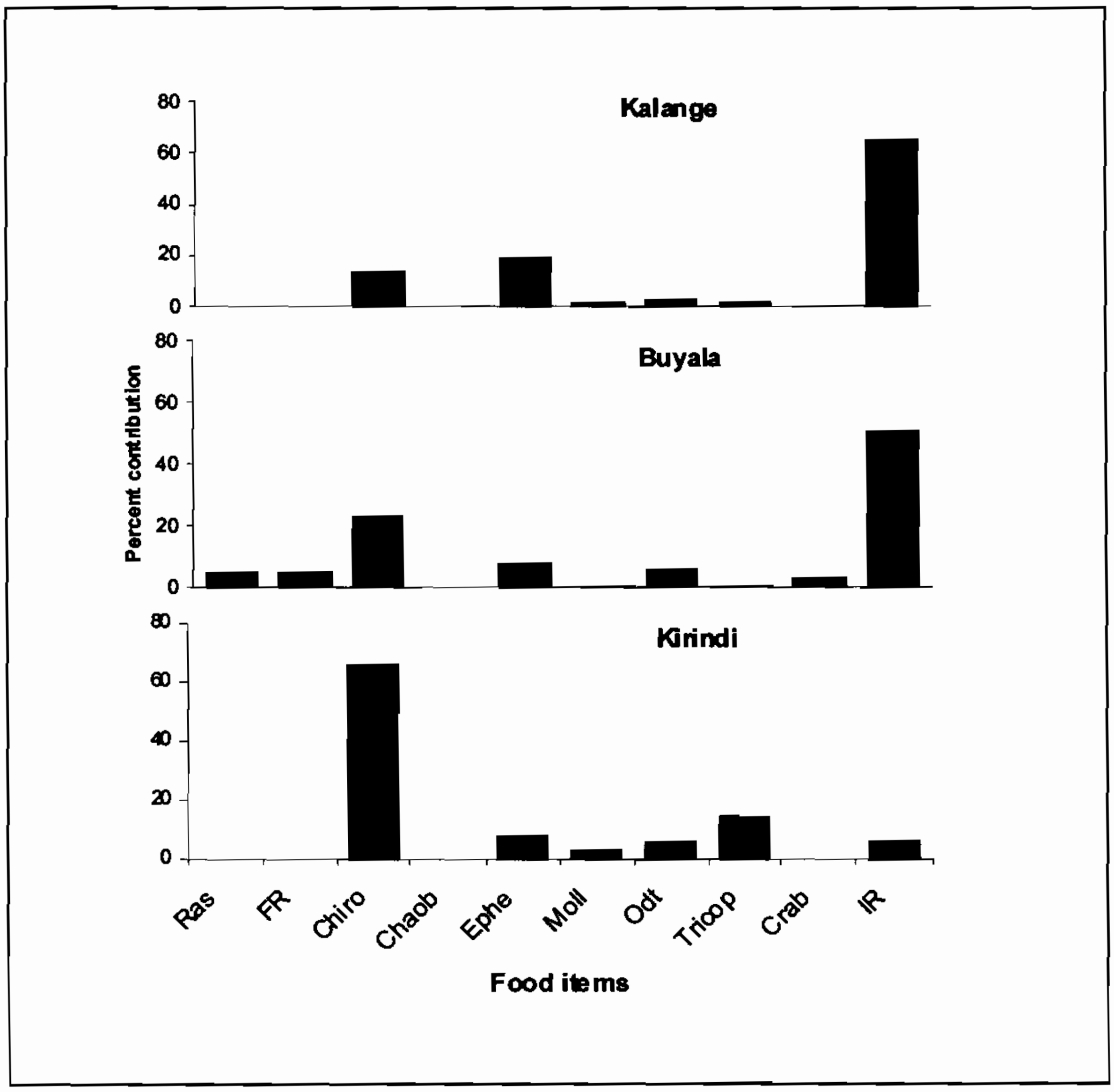


Fig. 9.1. The relative importance of food items in the diet of *Mormyrus kannume* caught at the 3 transects along the Victoria Nile.

Ras = *Rastrineobola argentea*; FR = Fish remains; Chiro = chironomid; Chaob. = Chaoborid; Ephe. = Ephemeroptera; Moll. = Mollusc; Odt. = Odonata; Tricop. = Trichoptera; IR = Unidentifiable insect remains

9.3.1b. *Lates niloticus*

As in previous surveys, *Lates niloticus* had ingested mostly fish prey which was dominated by haplochromines, *Clarias* sp. and unidentified fish remains (Fig. 9.2). Other prey items included *Caridina nilotica*.

CHAPTER 9

9.0. Biology and Ecology of Fishes

9.1. Introduction

Fish are among the major components of aquatic ecosystems that may be adversely impacted by hydropower projects along rivers. Some of the ecological aspects of development that may affect fish are changes in water flow, characteristics of new water regimes and interruption in breeding for those fishes which are migratory. Changes in composition of food organisms may also affect the ecology of fishes. As riverine fishes are important in the socio-economic livelihood especially of the riparian communities, baseline information on the ecology of fish populations prior to development is very important. In this report, the biology and ecology of the fishes occurring between an upstream of the proposed project transect and 3 downstream transects was studied and compared with similar studies conducted in April 2000 in the same transects. Two main aspects have been evaluated – the feeding ecology and breeding (egg production).

9.2. Materials and methods

Stomach content analysis and fecundity were conducted as detailed in the report of the previous AESNP Survey of April 2000.

9.3. Results

9.3.1. The food and trophic ecology of the fishes

Six fish species were used as indicators of trophic ecology. They included *Mormyrus kannume* and *Lates niloticus* in most sites, *Synodontis afrofischeri* and *Gnathonemus victoriae* from Kalange and Namasagali transects; *Oreochromis variabilis* from Kalange and *T. zillii* from Kalange, Buyala and Namasagali

9.3.1a. *Mormyrus kannume*

In all the sites where it occurred most abundantly, Transect 1 to 3 (corresponding to Kalange, Buyala and Kirindi) respectively, *Mormyrus kannume* fed mostly on insects which included chironomids, Ephemeroptera, Trichoptera, and unidentified insect remains. Other prey items included *Rastrineobola argentea*, unidentified fish remains, molluscs and crabs. The relative importance of food items in the diet of *M. kannume* is shown in Fig. 9.1.

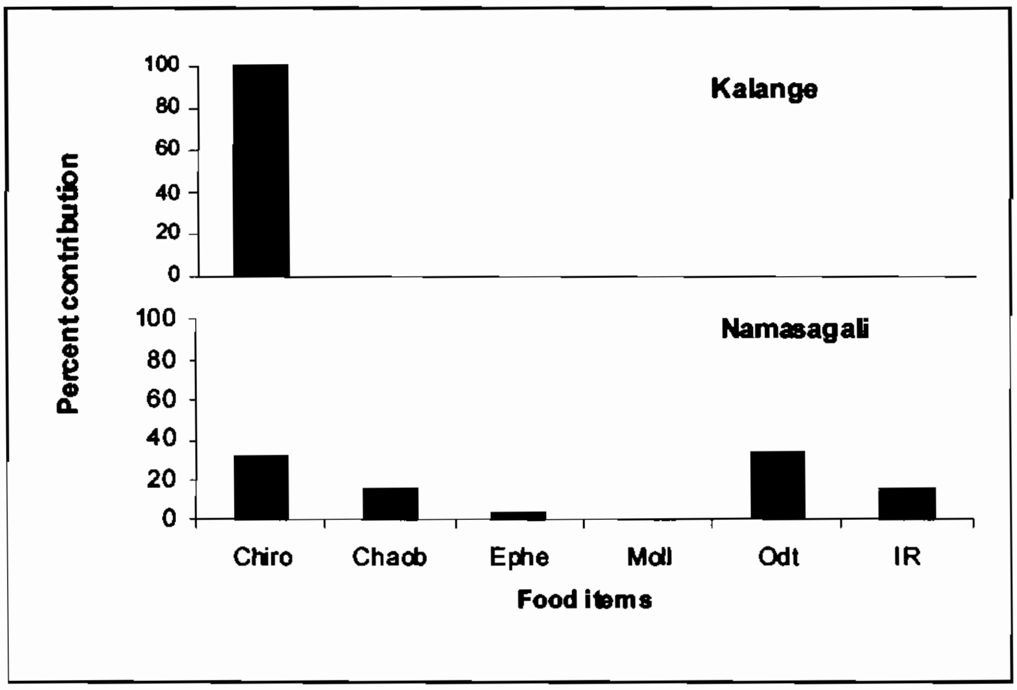


Fig. 9.3. The relative importance of food items in the diet of *Synodontis afrofischeri* caught at the two transects along the Victoria Nile.

9.3.2d. Food of other fish species

Among the tilapiines, only *Oreochromis variabilis* and *Tilapia zillii* had stomachs with food contents. In *O. variabilis*, the food items included algae (63.9%), detritus (32.4%) and high plant material (3.6%), while in *Tilapia zillii*, the dominant food item was algae (94.1) followed by high plant material (4.6%) and detritus (4.6%). There were no *O. niloticus* specimens with stomach contents.

Bagrus docmack fed predominantly on fish prey (60%) and Ephemeroptera (40%) while *Gnathonemus victoriae* fed exclusively on chironomids.

9.3.3. Fecundity (egg production)

Fecundity was only assessed in *Oreochromis niloticus* where only one ripe female was recorded with a fecundity of 4414 eggs. This was higher than in the survey of April 2000 where the only female specimen recorded had a fecundity of 1922 eggs. The mormyrids were not considered for fecundity studies because most of the ripe female had partially shed the eggs while in *Lates niloticus* there were no ripe female specimens recovered in the catches.

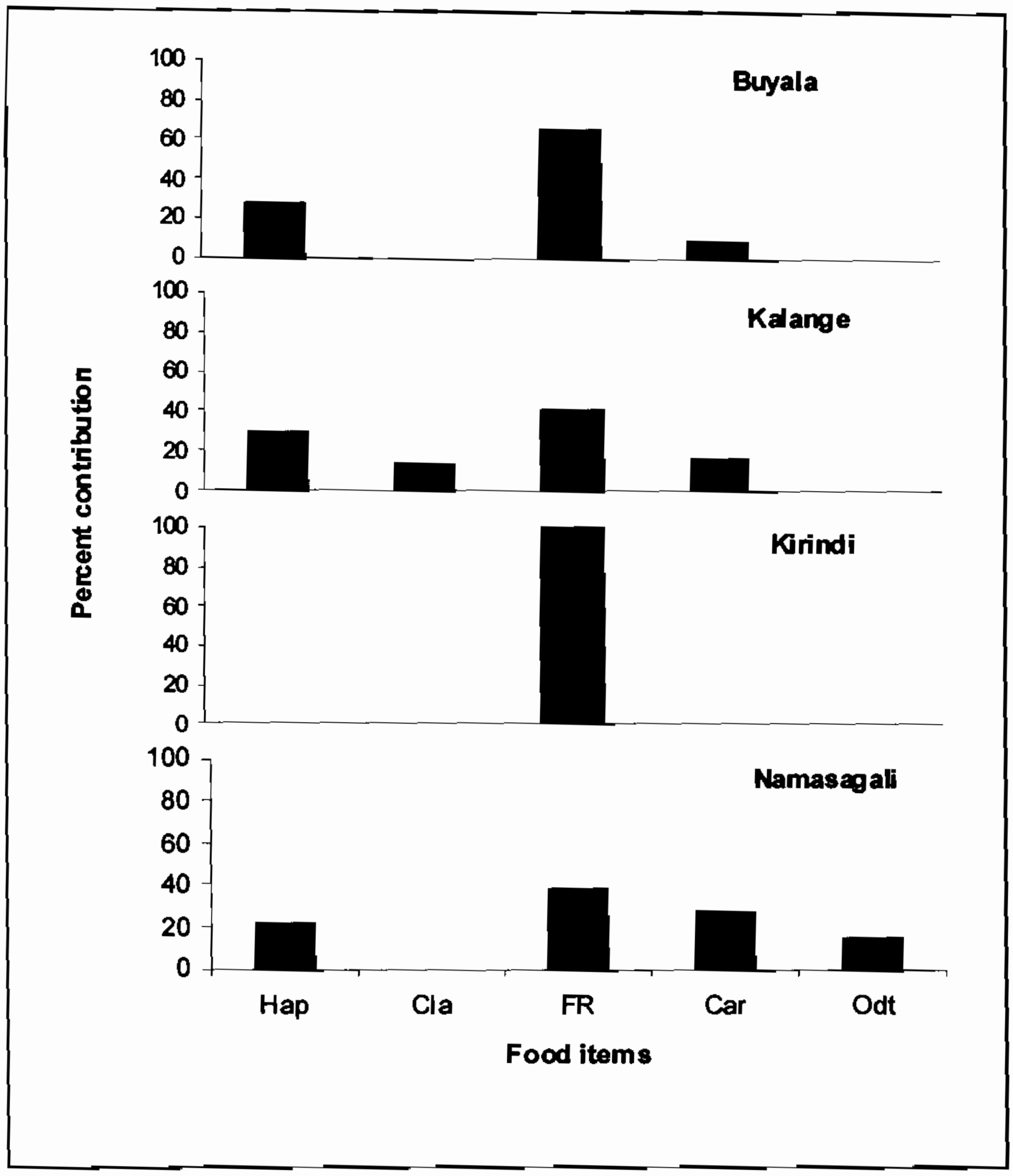


Fig. 9.2. The relative importance of food items in the diet of *Lates niloticus* caught at the four transects along the Victoria Nile

Hap. = haplochromines; Cla. = *Clarias* sp.; FR. = Unidentifiable fish remains; Car. = *Caridina nilotica*; Odt. = Odonata

9.3.2c. *Synodontis afrofischeri*

The main food of *Synodontis afrofischeri* during this survey was chironomids (35.7%), Odonata (32.1%), chaoborids (14.3%), unidentified insect remains, (14.0%), Ephemeroptera (3.6%) and molluscs (0.3%). This contrasted with results obtained in the April 2000 survey results in which the dominant food items were Isoptera.

CHAPTER 10

10.0. The Fishery Catch Survey

10.1. Background

Fish and fish products in Uganda are very important as a source of food, income, export earnings and employment. The higher diversity of fish species also attracts global attention in evolutionary studies. The fishery sector is directly employs more than 350,000 people and indirectly over 1.2 million people. Fish is the cheapest source of animal protein in Uganda. In 2005, it is estimated that fish exports earned Uganda US $ 142 million up from US $ 103 million in 2004, making it almost the first most important non-traditional export commodity. Despite the importance of the fishery industry to the people that live along the Victoria Nile, the amount of fish caught from the river is not known. The existing fishery is basically subsistence and the fishing is mainly done using cast nets, hooks (long line and angling) and to a lesser extent gill nets.

Tapping the hydropower potential of Victoria Nile like any other developmental project on a natural resource has to comply with legal provisions governing projects of this nature in Uganda (NEMA, 1996). Environmental Impact Assessment (EIA) for the proposed development has to be undertaken to evaluate among other issues, fishery related aspects relevant to the development. This report is therefore an update of EIA findings based on a field commercial fish catches study of the same project area and/or period covered during the 2000 surveys as a first study during the pre-construction phase.

10.2. Materials and Methods

A fish catch survey of the first quarter (corresponding to AESNP second quarter period 2000) of the study was conducted during April 2006 at four transects (one upstream and three downstream of the proposed hydro electric power site at Dumbbell island. Within each transect the names of major fish landing sites which were accessible were sampled along with the records of the number of active boats at each landing site. The types of full time jobs supported by the fishery were recorded by gender at the time of sampling.

For each sampled boat the following information/records were made:

Date of sampling, boat type, season, number of days the fisher goes out fishing per week, whether day or night catch, type of propulsion, number of crew per boat, gear type, size and number per boat, types of species caught per gear, gear size and fishing method, total weight of individual fish species per gear, gear size fishing method and

9.4. Discussion

Results of the food analysis indicate that *L. niloticus* and *B. docmack* were the main predatory fishes in the sites surveyed although in Buyala *M. kannume* was found to have included *R. argentea* and unidentifiable fish remains in its diet. However, insects especially chironomids were the main food items ingested by all the fish species recorded in the catches. Other food items included molluscs, *Caridina* and crabs. High plant material was an important food item for *T. zillii* and *O. variabilis.* Thus vegetation dominated habitats are important in the food web of the Upper Victoria Nile probably because, in addition to being a food item for the tilapiines, they are also an important habitat for other organisms especially insects, which are an important food item for most of the fish species recorded in the catch.

Higher densities of breeding adults of mormyrids were encountered as in the previous sampling of April 2000.This seems to be correlated with the onset of breeding triggered by the onset of the rain season. Despite the large number of *Lates niloticus* recorded from the experimental gillnets and *O. niloticus* purchased from the commercial fishers, only 1 specimen of *O. niloticus* had ripe gonads and no breeding specimen was recorded for *L. niloticus* For *L. niloticus* this observed trend may be due to absence of adult specimens (>50 cm TL) which usually have ripe gonads while for *O. niloticus* it was not yet peak breeding recorded. In April 2006, only one at Kalange was in place. Only Namasagali had two Askalis at the fish landing site (April 2000) compared to one in April 2006.

10.3.3 Importance of commercial and local food fish species being caught in transect 1-4

Based on percentage composition by weight of different fish species caught by different gears (Tables 10.2-10.4) *Oreochromis niloticus* remained the most dominant 75.8% compared to 81%, in transect 1, *Mormyrus kannume* (32.6%) also remained dominant compared to (29.8%), in transect two, *Rastrineobola argentea* (91.9%) was dominant compared to *Lates niloticus* (63%) and transect three *Barbus altianalis* (38.5%) compared to *Bagrus docmak* (100%) in the second quarter of 2000 survey. Over all of the four transects (Table 10.5) *R. argentea* contributed highest percentage by weight (62%) compared to *O. niloticus* (53.2%) in the similar quarter of 2000 survey. Unlike in the second quarter of 2000, where *O.niloticus* was the most dominant in all transects except transect 3, in this quarter it was only dominant in only transect four Namasagali. Higher catches of *O.niloticus* were from hook operations unlike in the second quarter of 2000 where Cast nets had catches higher. *O. variabilis* like in the second quarter of 2000 remained restricted to transect one Kalange. Like in the second quarter of 2000 *C. gariepinus* was only recorded in transect four Namasagali. *Protopterus aethiopicus* which had been encountered in the second quarter of 2000 was missing in the catches during this quarter. Haplochromine fish species also appeared in the catches but had not been recorded in the second quarter of 2000.

A total of 12 different fish taxa were recorded along the Victoria Nile compared to 10 fish taxa during second quarter of 2000. Noted absent in the second quarter was *P. aethiopicus* while haplochromines and *R. argentea* were recorded in this quarter but were absent in the second quarter of 2000. Most importantly, *R. argentea* contributed the highest percentage by weight in this quarter.

10.3.4 Size structure of major commercial fish species

The size structure of various major fish species encountered are shown in Figs 10.1 – 10.4. The major fish species were encountered in transects one, two and four where there were reasonable numbers (≥30 specimens) for frequency analysis. The size range of *T. zillii* from castnet catches (transect 1 at Kalange) was 12 - 31 cm TL (mode 20–21 cm TL) compared to 18 - 31 cm TL (mode 24-27 cm TL) at the same transect for the second quarter of 2000 (Fig.10.1)

At Kalange transect one, there were few specimen of *O. niloticus* (19) for frequency analysis from Cast nets compared to (14) in the second quarter of 2000. However, these had a size range of 15 -33 cm TL compared to 16 – 49 cm TL in the second quarter of 2000. This slight shift in the range could be explained by the shift in mesh size from 4" and 5" in the second quarter of 2000 to 3" in this quarter.

the total length of each species were measured. The fishers provided information on the price (Shs/kg) of different fish species at the sampled landing sites.
The procedure used for estimation of fish catch was outlined in the first quarter report 2000 (AESNP, 2000) and was again followed during April 2006.

10.3 Results

10.3.1 Fishing effort at landing sites sampled

The active boats operating in the transects and those sampled in the April 2000 and April 2006 are shown in Table 10.1. Out of the 51 active boats at the landing sites in the 4 transects, 37 (73%) were sampled compared to (46) 92% of the 50 active canoes sampled during the second quarter of 2000 survey. The active canoes comprised, 57% Ssese compared to 12%, 39% compared to 50% dug out canoes and 4% compared to 38% parachute in a second quarter of 2000 surveys. It is important to note that Ssese and parachute are all planked canoes but parachutes have flat bottom while Ssese canoes have the bottom plunks that meet at an angle. In the present sampling, these different types have been distinguished. For the sampled canoes, 67% compared to 13% were Ssese, 30% compared to 54% were dug out and 3% compared to 33% were parachute.

10.3.2 Fulltime jobs supported by the fishery

Boat builders increased from 6 men to 12 men (Table 10.1). Namasagali (transect four) and Buyala (transect two) recorded 5 men each compared to 2 men and 3 men in the similar quarter of 2000 survey. Kalange (transect one) recorded 2 men compared to 1 man and Kirindi 1 man compared to none in the similar quarter of 2000 survey. Though not directly investigated in this survey the possibility of migration of these boat builders within the four transects should be considered.

There was a noted decrease of (33%) of food vendors from 9 in April 2000 to 6 in April 2006. The men and women were one and 8 respectively (April 2000) compared to one man and 5 women in April 2006, a reduction of 37.5% in female vendors. There were no net repairers in April 2006 while one man was operating at Namasagali in April 2000. Men cleaning the fish landing sites were at Namasagali (one in April 2000 and two in April 2006).

89 fishers operated at the sampled fish landing sites in April 2000 compared to 128 in April 2006, an increase of 43.8%. Fish traders were 22 in April 2000 compared to 47 in April 2006, an increase of 114%. Men fish traders were 7 in April 2000 and 25 in April 2006 while females were 15 (April 2000) and 22 (April 2006).

Chairpersons of fish landing sites increased from one (April 2000) to three in April 2006. In April 2000, the only one Chairperson was at Namasagali while in April 2006 two were recorded at Kalange and Kirindi unlike in April 2000, where four fisheries staff were

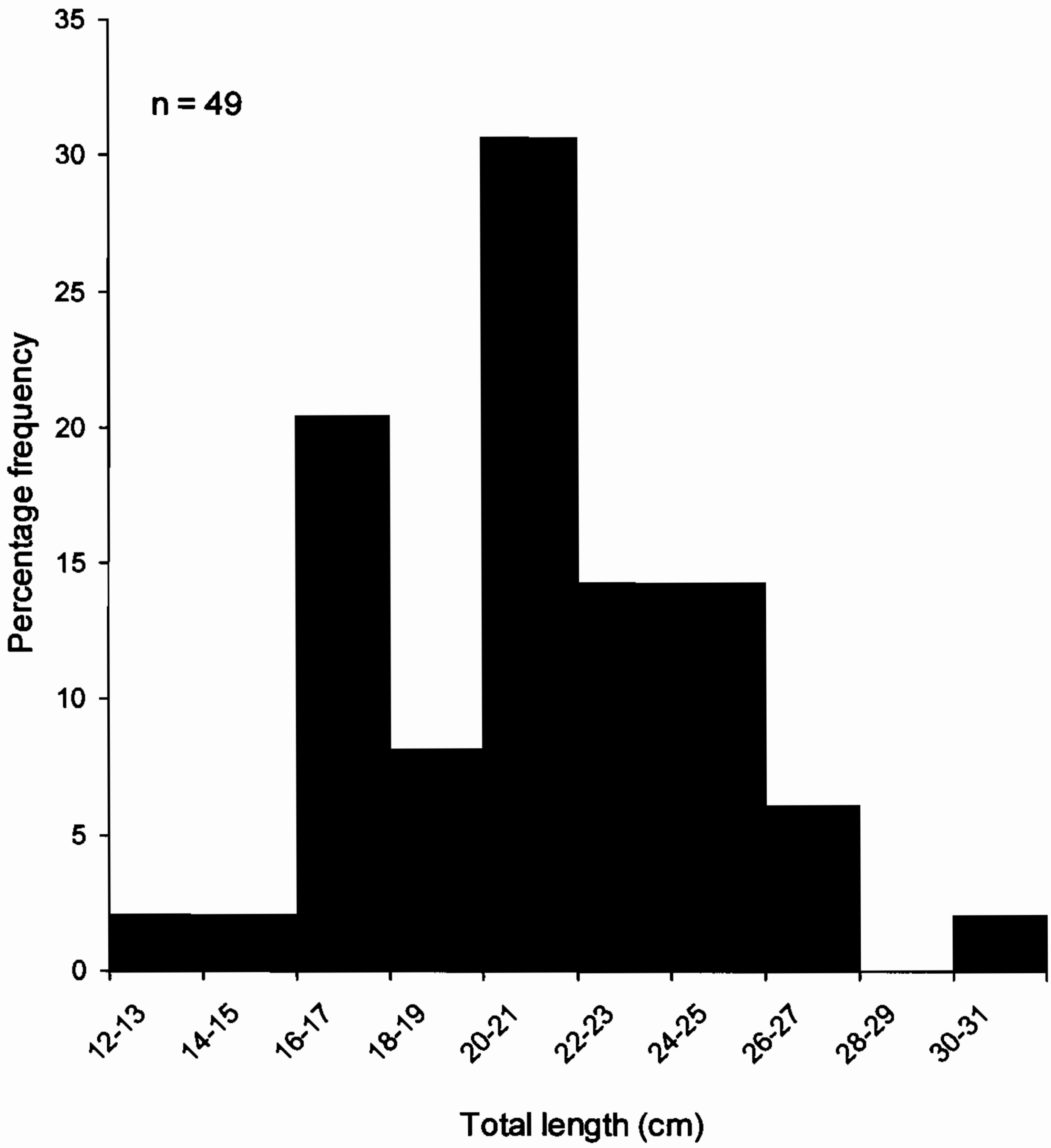


Fig. 10.1. Length frequency distribution of *Tilapia zillii* from commercial catches of cast nets transect one (Kalange-Makwanzi-upstream of Dumbbell Island) -2 cm intervals

There were very few (25) *L. niloticus* specimen from cast net catches at Kalange. However, these had a size range of 21-35 cm TL compared to a size range of 22-37 cm in second quarter of 2000. Like in the second quarter of 2000 they were all immature.

At Namasagali (transect four) the *O.niloticus* catches from gill nets, the size frequency distribution is shown in Fig. 10.2. The mode was at 29-30 cm TL compared to 33-36 cm TL and range was 25-36 cm TL compared to 27-48 cm TL in second quarter of 2000. All fish were mature.

M. kannume commercial gillnets catches in transect one – (Kalange) for the this quarter had a bimodal of 40-41 and 44-45 compared to 38-39 cm TL in the second quarter of 2000 and size range was 28-67 cm TL in this quarter compared to size range of 34-57cm TL in the second quarter of 2000 (Fig. 10.3) The mesh size of nets varied slightly (4" – 5") in second quarter of 2000 compared to 3.5" – 5") in this quarter (Table 10.6)

Rastrineobola argentea was, like in the AESNP fourth quarter report of 2000, recorded at transect two and was harvested by the 2mm mesh size mosquito seine net applying one lamp compared with a 3 mm mesh size scoop net of fourth quarter 2000. The mesh size harvested mainly juvenile fish of size range 14 mm – 33 mm SL with a mode at 22-23 mm SL (Fig. 10.4)

There was no length frequency analysis in this quarter for catches from Angling and Longline in transect four at Namasagali because the specimens were too few for such analysis compared to second quarter of 2000 where *O. niloticus* from longline and angling in transect four at Namasagali both had similar mode (25-26 cm TL). However size of Angling hooks and long line hooks changed from 6-14 to 10-12 and 7-12 to only 7 in second quarters of 2000.

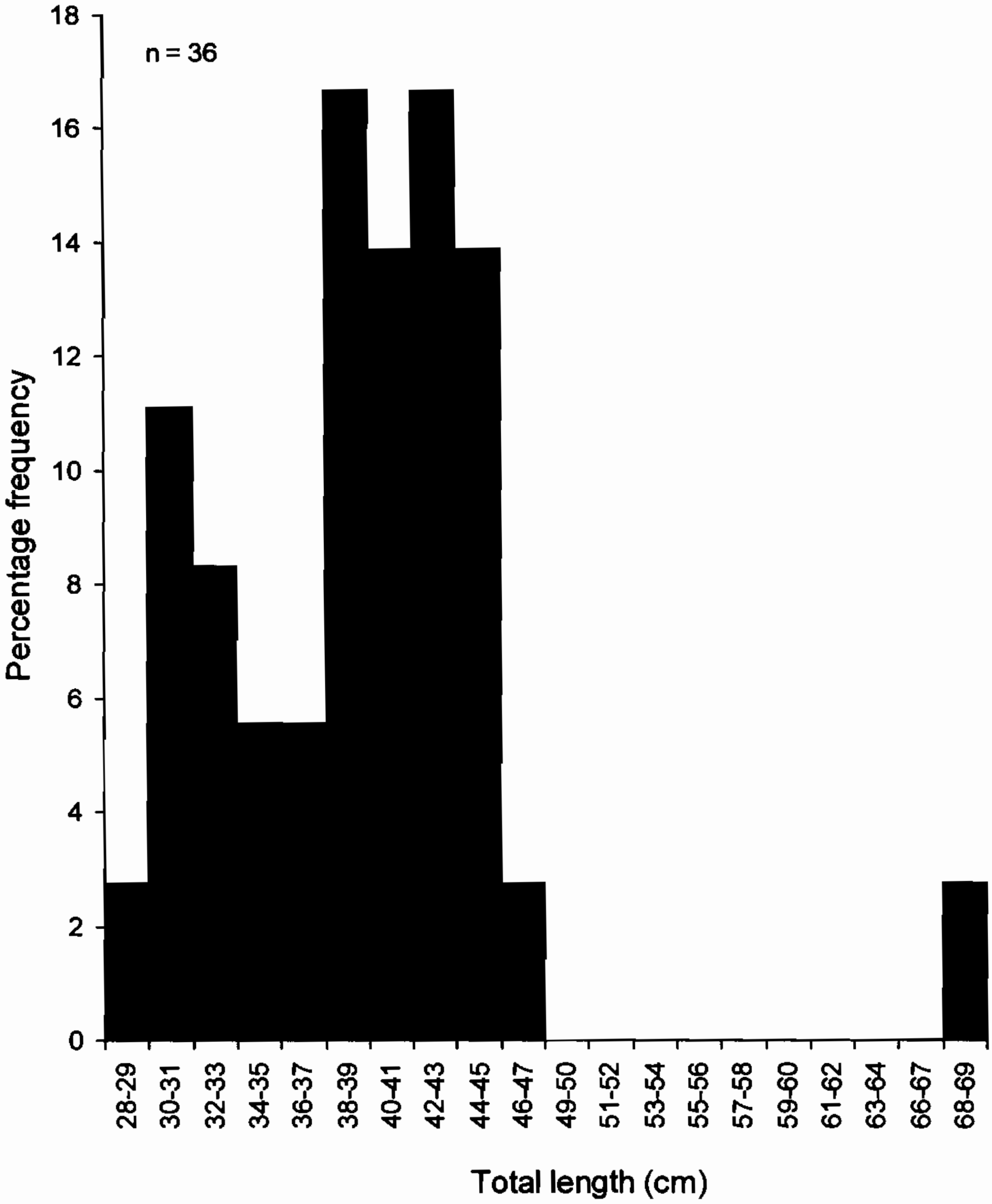


Fig. 10.3. Length frequency distribution of *Mormyrus kannume* from commercial catches of gill nets transect four (Namasagali – downstream of Dumbbell Island) 2 cm interval.

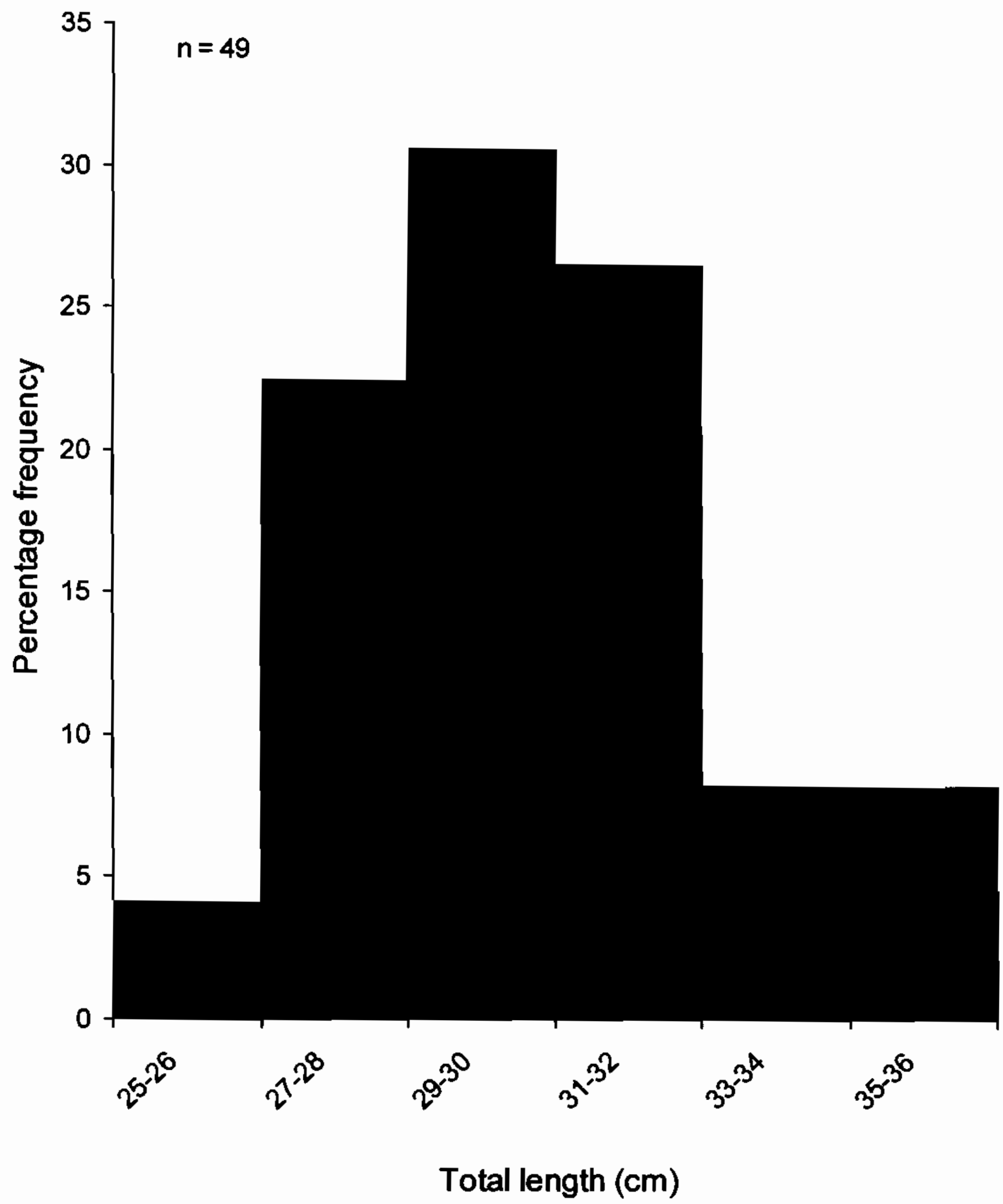


Fig. 10.2. Length frequency distribution of *Oreochromis niloticus* from commercial catches of gill nets transect four (Namasagali -downstream of Dumbbell Island) 2 cm intervals

10.3.5. Estimates of total yield

10.3.6. Fish catch estimates

The composition of fish catch, average fishing days per week, average gear per canoe and fishing methods and gear sizes are shown in Table 10.6. Like in the second quarter of 2000, there was variation in the average number of gear per canoe but the size of gears did not change significantly. In this quarter a new gear the seine net (mosquito net) of mesh size 2 mm targeting *R. argentea* was recorded in transect two Buyala.

10.3.7. Catch per unit of effort (CPUE)

The highest catch (kg) per canoe along transect 1-4 was from mosquito seine net catches 300 kg per canoe Buyala-Kikubamutwe (Transect 1), followed by gill nets at 15.6 kg/canoe and 14.3kg/canoe at Namasagali-Bunyamira (Transect 4) and Kalange-Makwanzi respectively. The least catches (0.4 kg/canoe) were recorded from longline at transect two Buyala-Kikubamutwe. Noted absent were catches from longline at transect one Kalange –Makwanzi which had contributed the highest catch per canoe during the second quarter of 2000 followed by gillnet catches at (14.7kg/boat) and 13.5 kg/canoe in castnet catches at Kalange – Makwanzi in transect one (Table 10.7).

The total estimated monthly fish yield was 16816 kg compared to 7,966.4kg in the second quarter of 2000 (Table 10.10). The increase by 66% is explained by the high catch rates of *R. argentea* recorded in transect two Buyala-Kikubamutwe, even though the catchability of the different fishing methods are not comparable.

10.3.8. Estimates for total commercial value of catch

The average cost prices of individual fish species obtained from fishers are shown in Table 10.11 for each transect. There was a general increase in prices of fish across the four transects but notable was for *L. niloticus*, *O. niloticus* and *B. docmak* that doubled in price wherever they were encountered and *M. kannume* that increased more than three times in price at transect one Kalange Makwanzi compared to the second quarter of 2000.

The estimated monthly fish value obtained was 12.1 million Ugandan shillings compared to 4.02 million Uganda shillings obtained in second quarter of 2000.

10.3.9. Non-commercial uses of fish.

As reported in the second quarter of 2000, there was no change of non-commercial uses of fish during April 2006.

10.3.10. Sport fishing

No sport fishing was observed in both this quarter and similar quarter of 2000.

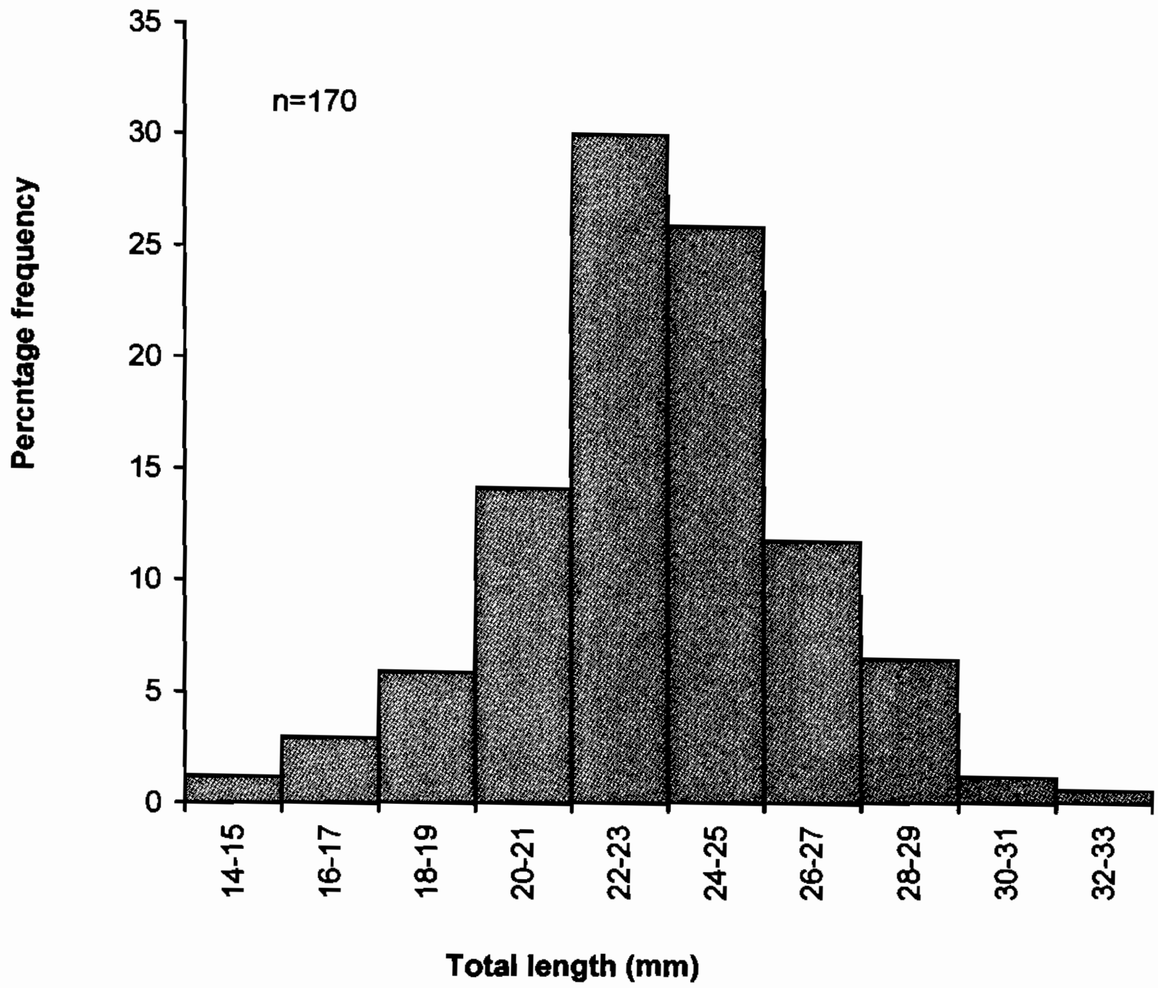


Fig. 10.4. Mukene (*Rastrineobola argentea*) length frequency distribution in (mm).

changes in the minimum mesh size 3" in this quarter from 4" in the second quarter of 2000 (Table 10.6.).

Changes in the average number of fishing gears was due to some fishers buying additional gear while others may have discarded old ones but the gear sizes did not substantially change as they are the sizes normally used to target particular fish species using a specific fishing method. The parameters used in fish catch estimates are shown in Tables 10.8 – 10.9

The total monthly catch estimates in this quarter was double (16815.9 kg) that of the second quarter of 2000 where as the value was three times (12.1m shillings) that recorded in the second quarter despite an almost no increase in the number of canoes (51) in this quarter and (50) in the second quarter of 2000. Correspondingly, the number of fishers and fish traders also increased and were 128 and 47 respectively in this quarter compared to 89 and 27 respectively in the second quarter of 2000. The increase in monthly catches is mainly attributed to the introduction of *R. argentea* fishery in transect two Buyala to Kikubamutwe which recorded the highest catch rate (300Kg/day/canoe) compared to 140 kg/boat (April 2000). The number of fishers and fish traders increased probably due to both the increase in catches and especially in price per kg of fish caught at almost all the transects. The increase in the observed monthly catches and prices explains the three-fold increase in value.

10.5. Summary

- A total of 37 canoes out of 51 active canoes were sampled in the four transects compared to 46 sampled canoes out of 50 active ones in the second quarter of 2000.
- The active canoes comprised the Ssese type (57%), dugout (39%) and parachutes (4%) where the sampled canoes comprised Ssese (67%), dugout (30%) and parachutes (3%) compared to active canoes, Ssese (12%), dugout (50%) and parachutes (38%) and sampled canoes; Ssese (13%), Dugout (54%) and parachutes (33%) in the second quarter of 2000.
- Full time jobs supported by the fishery included food vending and boat building.
- Food vendors were 6 people compared to 12 in the second quarter of 2000. Women made up 83% of the labour force compared to 77% in the second quarter of 2000. At Namasagali two men cleaned the landing compared to one in second quarter of 2000.
- Boat builders in all the four transects were 12 compared to 6 builders in the second quarter of 2000, chairmen of fishing landings remained three like in the second quarter of 2000 and the number of fisheries staff reduced from two in second quarter 2000 compared to one in first quarter of 2006.
- Fishers in this quarter were 128 compared to 89 in the second quarter of 2000 and fish traders were 47 (47% women compared to 60% in the second quarter of 2000) compared to 25 observed in the second quarter of 2000.
- The major fishing gears/methods were angling (40.5%), Gill nets (31.0%), long line (16.7%), Cast nets (9.5%) and Mosquito net (2.4%) of the sampled canoes.

10.4. Discussion

The overall number of active canoes at the landings in the four transects did not change significantly (51 active canoes and 50 active canoes in this survey and that of 2000 respectively) (Table 10.1). However there was an increase in transect 3 downstream (Matumu-Kirindi) where the number doubled from four to nine. This, like in the second quarter 2000 makes fishers switch from fishing to land tillage in preparation for crop planting. The increase in the number of active canoes at Kirindi could be explained by migration of fishers within transects manifested by a reduction in active canoes in Namasagali – Bunyamira (25-20), Buyala-Kikubamutwe (13-9) and Kalange-Makwanzi (9-6).

There was an overall reduction in food vending activities across the four transects as shown in the reduction in the number of food vendors from 8 (all women) to 6 (5 women and 1 man) and complete absence of food vendors in transect 2 (Buyala) and transect 3 (Kirindi). Food vending was dominated by women while fishing, boat building/repairing, fisheries staff, and chairpersons were dominated by men (Table 10.1). Absence of food vendors relates to the fishers not being permanently in the transects and thus participating in other activities like crop cultivation. No net repair was recorded at Namasagali compared to the second quarter of 2000 due to the continued reduction from 25 and 20 active boats in the first quarter 2006 and second quarter 2000 respectively. Despite the a slight increase in the number of active canoes across the four transects, the number of fishers and fish traders increased mainly due to the observed general increase in fish prices per fg (Table 10.11).

The number of species caught by fishers along the Upper Victoria Nile increased slightly from 10 in second quarter 2000 to 12 fish taxa in second quarter 2006 respectively because haplochromines and *R. argentea* not previously recorded were encountered in this quarter. The percentage contribution of the haplochromines to the overall catches was negligible (>0.1%) compared to that of *R. argentea* which contributed (62%) overall and 91.9% in transect 2 Buyala-Kikubamutwe. It should be noted that *R. argentea* was only being fished in transect 2 (Buyala-Kikubamutwe) and information was recorded from one canoe out of the total two that fish for it in transect two. *P. aethiopicus* which had been recorded in the second quarter of 2000 did not appear in the catches during second quarter 2006.

At Kalange (Transect one), cast net fishers during first quarter 2006 were using mesh size 3" compared to mixed mesh sizes 4" – 5" in the second quarter of 2000. However, the size range of *O. niloticus* caught was 15-35 cm TL compared to 16-49 cm TL in the second quarter of 2000. This is explained by the corresponding shift above in mesh sizes used.

The size of *M. kannume* in commercial catches at Kalange (Transect one) varied with a bimodal 40-41 cm TL and 44-45 cm TL compared to mode 38-39 cm TL, range 28-67 cm TL compared to 34-57 in second quarter of 2000. This was mainly attributed to the

Table 10.1 The composition of fish catch survey information of April 2006 compared with second quarter April 2000 survey (in brackets) at the four sampling transects of the upper Victoria Nile. D= Dugout: S=Ssese: Pa=Parachute

Parameters	Transect 1 Upstream Kalange to Makwanzi		Transect 2 Downstream Buyala to Kikubamutwe		Transect 3 Downstream Matumu to Kirindi		Transect 4 Downstream Namasagali to Bunyamira	
Major landing sites								
Active canoes	9S(6 Pa, 6S)		13S (8Pa, 1D)		7S, 1Pa, 1D (2Pa, 2D)		19D, 1Pa (22D, 3Pa)	
Sampled canoes	9S (6 Pa, 6S)		9S (6Pa, 1D)		7S, 1Pa, 1D (2Pa)		10D (24D, 1Pa)	
Jobs supported by the fishery	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**
Boat builders/repair	2 (1)		5 (3)		1 (-)		5 (2)	
Food vendor		4 (4)	- (1)	- (4)			1	1
Net Repairer							- (1)	
Cleaner fish landing							2 (1)	
Fishers	57 (22)		26 (9)		5 (12)		40 (46)	
Fish traders	11 (3)	12 (7)	5 (3)	8 (7)	1 (1)	2 (1)	8	
Chairperson	1				1		1 (1)	
Fisheries staff	1 (1)		- (1)				- (2)	
Askali landing site (securicor)							1 (2)	

NB: Localities associated with all the transects in all the Tables are: Transect 1 upstream include: Kikonko, Kunjaba, Makwanzi Is, Transect 2 downstream include: Naminya, Kisadha, Ofwono, Zaire, Mugalya, Kisoga, Transect 3 downstream include: Matumu, Kisoga A,B,C, Damba, Transect 4 downstream include: Kasanga, Kibuye, Sajjabi

In the second quarter of 2000, of the sampled canoes, Angling and long line contributed 34.8% each of the sampled canoes, gill nets (21.7%) and cast nets (8.7%).

- The major commercial fishery along the Victoria Nile transects in order of importance ware *R. argentea* (62%), *O. niloticus* (11.5%) *M. kannume* (6.1%), *L. niloticus* (5.8%), *B. docmak* (5.4) and *B. altianalis* (4.9%) in the first of 2006. In the second quarter of 2000 *O. niloticus* contribution was (53.0%), *M. kannume* (13.6%) *L.niloticus* (13.5%) and *B. altianalis* (5.7%).
- The importance of fish species in commercial catches along the Victoria Nile changed slightly to include *R. argentea* as the most import fishery and *B.docmak* which became less important in the fishery was 5.4% compared to 2.4% in the second quarter of 2000.
- The highest CPUE was in transect two (300 kg per canoe) compared to transect one (140 Kg/canoe) in second quarter of 2000.
- The total monthly yield estimates from the 4 transects was 16816 kg compared to 7969.4kg in second quarter of 2000 and the estimated monthly fish value was 12.09 million Uganda shillings compared to 4.02 million in the second quarter of 2000.
- As was the case in the second quarter of 2000, there was no sport fishing.

10.6. Conclusion

The estimated monthly catches doubled and the value increased by three times those of the second quarter of 2000, mainly due to the increase in fish prices and capture of *R. argentea* that recorded the highest catch rate per canoe per day (300 kg). Correspondingly the same two factors led to an increase in the number of fishers (89 to 128) and fish traders (22 to 47). The highest monthly yield estimates were got in transect two (16815.9 kg valued at 9.8M) and transect four (2042kg valued at 1.74M) and the least was transect three 669 kg valued at 0.43 compared to 3637.7 kg valued at 1.81M, in transect four and 3421.7kg valued at 1.72M in transect one and the least was in transect three 308.0 Kg valued at 0.09M of the four transects along Victoria Nile in the second quarter of 2000. Transect four (Namasagali) had the highest fishing effort (20 canoes) as was the case in the second quarter of 2000 but the number had reduced by five canoes (20%).

However the highest CPUE (catch kg per canoe) was in transect two at 300 kg per canoe compared to transect one at 16.7 kg per canoe in the second quarter of 2000. The gears and fishing methods in order of importance were angling (40.5%), followed by gill nets (31.0%), and long line 16.7% for the fishing canoes sampled. The *R. argentea* was the overall most dominant species (62.0%) compared to *O. niloticus* (53.2%) in the second quarter of 2000. A total of 12 fish species were recorded compared to 10 in the second quarter of 2000. However, *P.aethiopicus* was not encountered. The highest number of fish species (8) were in transect one followed by transect 2 and 4 each with 6 species.

Table10.4 Records of the commercial and local fish species caught and their percentage composition by weight (kg) in angling catches compared with second quarter 2000 (in brackets) at the four sampling stations of the upper Victoria Nile

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira
Angling				
O. niloticus	75.6 (76.6)	2.8		84.9 (77.2)
O. variabilis	- (9.7)			
T. zillii	2.8 (7.7)	0.8		
L. niloticus	13.2 (13.9)	19.5 (88.0)	69.2	15.1 (22.5)
M. kannume	8.4	7.2		
B. altianalis		5.0	30.8	- (0.3)
B. docmak		64.1 (12.0)	- (100.0)	

Table 10.5. Overall percentage composition by weight (kg) compared with second quarter 2000 (in brackets) at the four sampling stations of the upper Victoria Nile

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira	
O. niloticus	22.4 (26.8)	0.2		75.8 (81.0)	11.5 (53.2)
O. leucostictus	0.8 (0.4)			2.3	0.1 (1.4)
O. variabilis	4.6 (10.0)				0.7 (4.3)
T. zillii	17.8 (7.7)			2.0	3.0 (3.3)
L. niloticus	15.3 (14.7)	1.5 (63.0)	25.0	8.1 (8.8)	5.8 (13.5)
M. kannume	32.6 (29.8)	1.2 (15.1)	4.1	(0.5)	6.1 (13.6)
B. altianalis	6.3 (5.1)	0.3	38.8	11.4 (6.7)	4.9 (5.7)
B. docmak	- (0.1)	4.9 (22.0)	32.4 (100.0)		5.4 (2.4)
P. aethiopicus	- (3.7			(6.7)	(1.9)
C. gariepinus	- (1.8)			2.7	0.3 (0.8)
R. argentea		91.9			62.0
Haplochromines	0.1				

Table 10.2. Records of the commercial and local fish species caught and their percentage composition by weigh (kg) in individual gears compared with second quarter 2000 (in brackets) at the four sampling stations of the upper Victoria Nile

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira
Composition in gillnets				
O. niloticus	3.2 (18.0)			78.2 (69.8)
O. leucostictus	- (0.6)			- (1.8)
O. variabilis	3.0 (4.4)			
L. niloticus	7.5 (8.2)	15.6 (39.0)	31.6	
M. kannume	69.5 (64.6)	33.6 (61.0)	68.4	- (2.0)
B. altianalis	15.3 (4.0)			15.4 (26.3)
B. docmak	- (0.3)	- (49.8)		
T. zillii	- (1.5			2.7
C. gariepinus				3.7

Table 10.3. Records of the commercial and local fish species caught and their percentage composition by weight (kg) in cast nets and hooks compared with second quarter 2000 (in brackets) at the four sampling stations of the upper Victoria Nile

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira
Castnets:				
O. niloticus	16.5 (27.1)			50.9
O .leucostictus	2.0 (0.5)			44.8
O. variabilis	8.5 (26.6)			
T. zillii	42.3 (31.0)			
L. niloticus	24.6 (8.9)			4.2
B. altianalis	15.3 (2.0)			
Haplochromines	0.3			
M. kannume	5.8			
Longline				
O. niloticus	(3.9)			
L. niloticus	(45.1)	(30.7)	15.2	100 (98.1)
M. kannume	(5.7)			
B. altianalis	(19.3)		43.1	
B. docmak		100 (69.3)	41.7	
P. aethiopicus	(6.0)			
C. gariepinus	5.3			1.9

Table 10.8. Estimates of the total yield (kg) per day compared with second quarter 2000 (in brackets) for sampled boats at the four sampling stations of the Upper Victoria Nile

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira
Total number of active boats at landing	9 (12.0)	13 (9.0)	9.0 (4.0)	20.0 (25.0)
Boats sampled	12 (9.0)	9 (7.0)	9.0 (9.0)	10.0 (25.0)
Average days fished/week	5.2 (6.1)	7.0 (7.0)	5.2 (7.0)	5.0 (4.6)
Yield estimates of species per day (kg)				
O. niloticus	8.3 (44.0)	0.5		38.7 (160.2)
O. leucostictus	0.3 (0.7)			
O. variabilis	1.7 (16.5)			(4.6)
T. zillii	6.6 (12.6)			1.0
L. niloticus	5.7 (24.2)	4.8 (10.5)	8.0	4.2
M. kannume	12.2 (48.9)	4.0 (2.5)	1.3	(17.4)
B. altianalis	2.4 (8.5)		12.4	5.8 (1.0)
B. docmak	(0.2)	15.9 (3.7)	10.4 (5.5)	(13.3)
P. aethiopicus	(6.0)			(1.2)
C. gariepinus	(2.9)			1.4
R. argentea		300		
Haplochromines	0.1			
Total weight (kg) landed per day	37.2 (164.5)	326.4 (16.7)	32.1 (5.5)	51.1 (197.7)

Table 10.6. The composition of fish catch survey fishing gears, fishing methods and size of gear compared with second quarter 2000 (in brackets)at the four sampling stations of the Upper Victoria Nile

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira
Av. gear per boat				
Gillnets	5.2 (6.6)	3.5 (2)	2 (-)	6.2 (4.3)
Castnets	1 (1)			- (1)
Angling (Hooks)	2 (2.3)	4.8 (2.8)	5.8 (-)	4.3 (5.1)
Longline (Hooks)	- (210)	40 (38.5)	68.5 (15)	29 (18.4)
Mosquito net		1 (-)		
Size of gear				
Gillnets	3.5"-5 (4"-5")	- (3")		5", 6" (4.5" ,6")
Castnets	3" (4/5'-4.5" – 4.5/5")		3" (-)	- (4")
Angling (Hooks)	10-15 (10-14)	7,8 (12,8)	7,8 (7)	10-12 (6,11,12,14)
Longline (Hooks)	- (8)	- (8)		7 (7,9,10,11,12)
Mosquito net		1mm (-)		

Table 10.7. The catch per unit of effort (kg) per boat, gear or fishing method compared with second quarter 2000 (in brackets) at the four sampling stations of the Upper Victoria Nile

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira
Catch per unit of effort per boat				
Gillnets	14.3 (14.7)	6.7 (4.1)	1.9 (-)	15.6 (12.4)
Castnets	8.6 (13.5)			- (8.3)
Longline	- (24.4)	0.4 (1.9)	10.0 (2.7)	2.5 (5.8)
Angling	7.1 (8.6)	12.2 (2.2)	3.4 (-)	5.5 (9.4)
Mosquito net		300 (-)		
Per gear				
Gillnets	1.2 (2.5)	1.1 (2.1)	1.0 (-)	1.2 (2.9)
Castnets	7.3 (13.5)			- (8.3)
Longline	- (0.12)	0.01 (0.05)	0.1 (0.23)	0.04 (0.3)
Angling	1.4 (3.7)	0.7 (0.2)	0.2	0.8 (1.8)
Mosquito net		300 (-)		

CHAPTER 11

11.0. Bilharzia, other Disease vectors and Status of Sanitation

11.1. Introduction

The study of bilharzia and snail vectors as well as other disease vectors such as *Simulium sp* and the effect of the extent of water quality to humans who use it for bathing, drinking and cooking, fishing, swimming is essential in baseline information and changes that may occur during and after dam construction. Bilharziasis (Schistosomiasis) is spread by two major snail vectors, *Biomphilaria spp* and *Bulinus sp.* The former is a vector of *Schistosoma mansoni* while the latter is a vector of *Schistosoma hematobium.* River blindness, one of the very dangerous disease for riparian communities along polluted rivers is spread by *Simulium* larvae. This report provides preliminary information on the prevalence and intensity of waterborne diseases mainly schistosomiasis and river blindness, and the sanitation status among the riparian communities along the Upper Victoria Nile.

11.2. Materials and Methods

11.2.1. Sampling for Bilharzia (schistosomiasis) snails

The snails were sampled by making 3 transects on both banks of the river at selected sites. Each transect measured one square metre. The snails were collected by hand picking from rocks and by use of a grab for the river bottom. These were the only viable methods due to the presence of rocks at the site, which made the conventional scooping method unsuitable. The vector snail samples were then placed in test tubes and water was added before they were exposed to sunlight for 2-4 hours to shed them for cercaria.

11.2.2. Sampling stool for parasitological analysis of Bilharzia in humans

Stool samples were obtained from the residents both male and females present at the landing sites, were involved. Consent was obtained from the residents and the local leaders were informed. High-risk water-human contact activities were determined as Fishing, Bathing/swimming, washing clothes, fetching water and playing.

The Kato-Katz stool analysis technique was used, whereby 41.7 mg of human faecal material was collected from each of the 15 people per selected site, giving a total of 60 samples from the people. Intensity of infection from these samples was determined by placing the faecal material on a slide with the aid of a template and a cellophane cover

Table 10.9. Estimates of total yield kg/month compared second quarter 2000 (in brackets) at the four sampling stations of the upper Victoria Nile

Parameters	Transect 1 Upstream Kalange to Makwanzi	Transect 2 Downstream Buyala to Kikubamutwe	Transect 3 Downstream Matumu to Kirindi	Transect 4 Downstream Namasagali to Bunyamira
Total yield (kg/week), kg/month				
O. niloticus	202.5 (915.2)	20.2 (-)		15448 (2947.7)
O. leucostictus	7.2 (14.6)			- (84.6)
O. variabilis	41.7 (343.2)			
T. zillii	160.9 (262.1)	6.1 (-)		40 (-)
L. niloticus	138.4 (503.4)	192.1 (378.0)	167.1 (-)	166 (320.2)
M. kannume	295.1 (1017.1)	161.8 (89.6)	27.2 (-)	- (18.4)
B. altianalis	57.1 (176.8)	40.4 (-)	258 (-)	232 (244.7)
B. docmak	- (4.2)	643.1 (134.4)	217.2 (308.0)	
P. aethiopicus	- (124.8)			- (22.1)
C. gariepinus	- (60.3)			56 (-)
R. argentea		12133.3 (-)		
Haplochromines	1.2 (-)			
Total	**904 (3421.7)**	**13200.4 (602.0)**	**669.5 (308.0)**	**2042 (3637.7)**

Table 10.10. Estimates of total cost per fish species per month and estimates of total value in millions of Uganda shillings at the four sampling stations of the Upper Victoria Nile

Parameters	Transect 1Upstream Kalange to Makwanzi		Transect 2 Downstream Buyala to Kikubamutwe		Transect 3 Downstream Matumu to Kirindi		Transect 4 Downstream Namasagali to Bunyamira	
	Sh/kg	Millions	Sh/kg	Millions	Sh/kg	Millions	Sh/kg	Millions
O.niloticus	750 (743)	0.15 (0.68)	500 (-)	0.01 (-)			100 (500)	1.55 (1.47)
O.leucostictus	500 (750)	0.004 (0.01)			1000 (-)	0.22 (-)	- (300)	- (0.03)
O.variabilis	550 (660)	0.02 (0.23)						
T.zillii	550 (600)	0.09 (0.16)					500 (-)	0.02 (-)
L.niloticus	900 (500)	0.12 (0.25)	2250 (700)	0.43 (0.27)	1250 (-)	0.21 (-)	1000 (350)	0.17 (0.11)
M.kannume	786 (220)	0.23 (0.22)	667 (600)	0.11 (0.05)			- (225)	- (0.004)
B.altianalis	800 (500)	0.05 (0.09)	1500 (-)	0.06 (-)			- (500)	- (0.12)
B.docmak	- (767)	- (0.003)	2000 (1100)	1.29 (0.15)	1000 (700)	0.22 (0.09)		
P.aethiopicus	- (220)	- (0.03)					- (200)	- (0.004)
C.gariepinus	- (875	- (0.05)					1400 (-)	0.08 (-)
R. argentea			**600 (-)**	**7.3 (-)**				
Haplochromines	**0.05 (-)**							
Total		**0.67 (1.72)**		**9.2 (0.47**		**0.43 (0.09)**		**1.74 (1.81)**

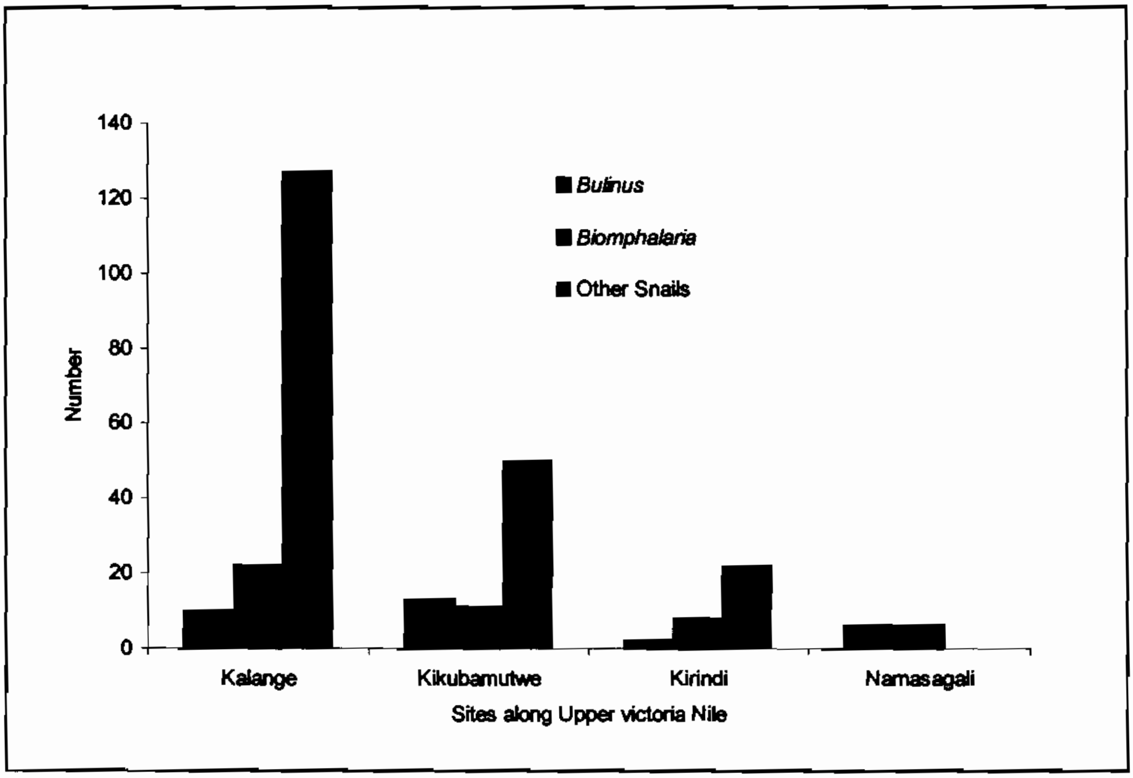


Fig. 11.1. Abundance and distribution of bilharzias vector (*Bulinus* and *Biomphalaria*) snails and non-vector (*Bellamya, Melanoides, Lymnaea* and bivalves) molluscs along the Upper Victoria Nile

11.3.2. Parasitological analysis of bilharzias in humans

Of the 60 samples collected from a population of 265 people, 50 % of the sampled population were infected with Schistosomiasis (Table 11.1).

slip dipped in malachite green. Samples were examined under a compound microscope for purposes of estimating the eggs per gram load (EPG).

11.2.3. Prevalence of schistosomiasis by different water users

Prevalence of schistosomiasis was evaluated for the following water contact activities: fishing, fetching water, bathing and swimming, playing and washing by taking sample populations of 14, 11, 10, 10, and 15 people, respectively covering the four transects.

11.2.4. Sampling for faecal coliforms

Samples were taken from one site from each of the 4 transects along the river for the purpose of testing for faecal coliforms. The sites were Kalange(Transect 1), Kikubamutwe (Transect 2), Kirindi (Transect 3) and Namasagali (Transect 4) at shallow fast moving waters and deep water points. Equipment was sterilised using methylated spirit. The water was filtered, a pad prepared and culture media (Mackonky's broth solution) was applied to the pad and incubated for 20-22 hours in line with the testing method using DelAgua Testing kit.

11.2.5. Sampling for *Simulium* (Blackfly) larvae

Samples of crabs and vegetation in fast moving waters of the river were collected and checked for *Simulium* larvae at the four transects.

11.3. Results

11.3.1. Bilharzia snails abundance and distribution

The non-vector snails were more abundant than the vector snails at three sites except Namasagali (Fig. 11.1). Of the vector snails, only two were infectious i.e. shed cercaria. One, a *Biomphalaria* was from Kalange and the other was *Bulinus* from Kikubamutwe (Transect 2). Though the number of infected vector snails were few, they may be quite significant in the spread of disease. Of the two vector snail species, *Biomphalaria sp.* was more abundant at Kalenge and Kirindi sites (Fig.11.1). The prevalence land is indicative of a higher risk of *Schistosoma mansoni* than *Schistosoma haematobium*. Kalange had the highest number of vector snails while Namasagali had the lowest. At all sites, the vector snails were encountered and thus their number, distribution and abundance could be a source of transmission. Shedding of cerceria by the *Bulinus sp* is indicative of transmission of *S. haematobium* that has not yet been clinically detected in Uganda and therefore merits further follow up.

11.3.3. Intensity of infection by schistosomiasis

Kalange and Namasagali have moderate to heavy intensity while Kirindi and Kikubamutwe have light to moderate intensity (Table 11.2). Thus, a concerted effort is needed to promote chemotherapy and environmental sanitation measures to reduce parasite loads and transmission in the riparian villages on Upper Victoria Nile

Table 11.2. Intensity of schistosomiasis infection

Site	Samples	Positive No.	Light intensity	Moderate intensity	Heavy intensity
Kalange	15	8 (53%)	1 (6.7%)	5 (33.3%)	2 (13.3%)
Kikubamutwe	15	7 (47%)	2 (13.3%)	4 (26.7%)	1 (6.7%)
Kirindi	15	7 (47%)	4 (26.7%)	2 (13.3%)	1 (6.7%)
Namasagali	15	8 (53%)	2 (13.3%)	4 (26.7%)	2 (13.3%)
Total	**60**	**30 (50%)**	**9 (15%)**	**15 (25%)**	**6 (10%)**

11.3.4. Prevalence of schistosomiasis by different water users

The major predisposing activities for Schistosomiasis infection were fishing and swimming/ bathing (Fig. 11.3). These activities therefore will form the focus of subsequent the health interventions.

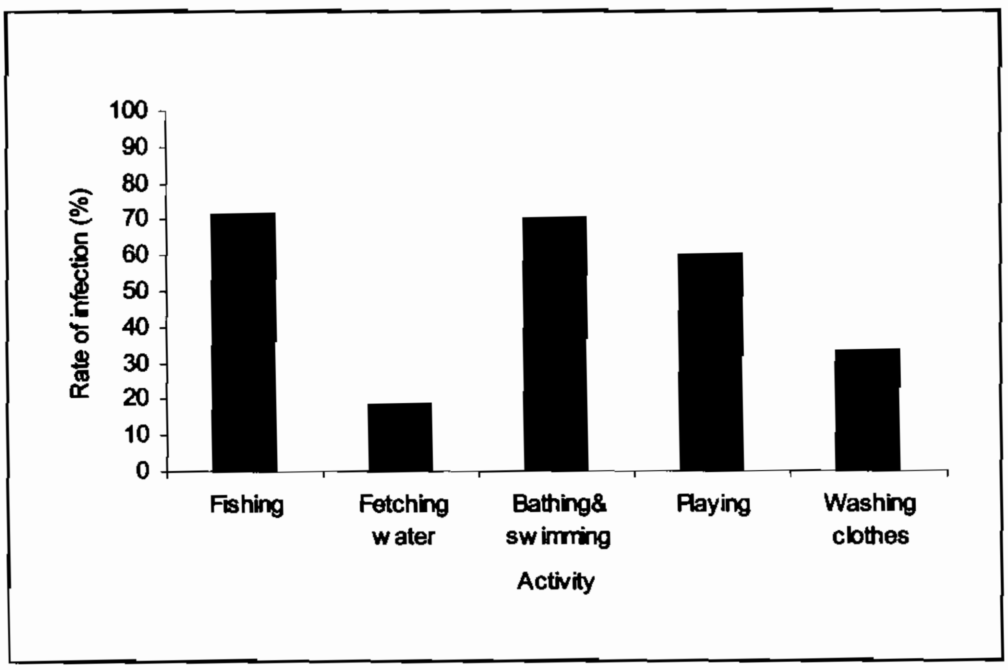


Fig. 11.3. Prevalence of schistosomiasis by water contact activities

Table 11.1 Sample population and samples collected at the sites along Upper Victoria Nile for prevalence of Schistosomiasis

Village	Site	Popn. at site	Samples collected	Positives
Buwenda	Kalange	65	15 (23%)	8
Kikubamutwe	Nankwanga	60	15 (25%)	7
Kirindi	Bukwaya	70	15 (21%)	7
Namasagali	Kabanga	70	15(21%)	8
Total		**265**	**60 (22.6%)**	**30**

Infection with schistosomiasis was highest (53%) in both Kalange and Namasagali (Fig. 11.2). It is especially significant in Kalange area when you find that there is presently an active deworming programme using mass chemotherapy with paraziquantal. This is indicative of a high rate of re-infection.

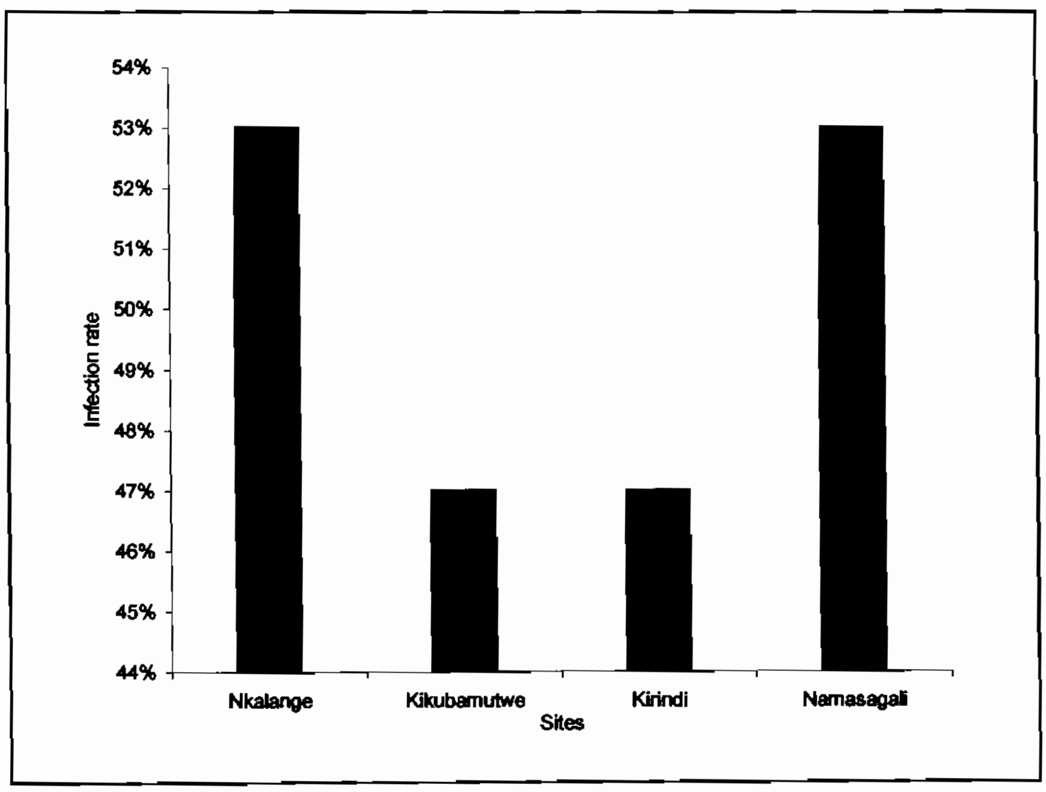


Fig. 11.2. The infection rate of schistosomiasis at four sites along the Upper Victoria Nile

12.0. Fisheries Socio-economics Findings

12.1. Objectives of the survey

The main objective of the survey was to provide baseline fisheries socio-economic information on activities in the project site.

12.2. Survey sites and tools

The survey was focused on the areas previously sampled during AESNP EIA 2000. Participatory Rural Appraisal tools including transect walks, focus group discussions and key informant interviews were used. Additional socio-economics information captured in meeting notes is not included in this report.

12.3. Populations and activities at sampled sites

The major economic activity prevailing in the sampled sites is predominantly agriculture with some smallholder fishing activity. Although fishing is largely carried out on a subsistence level, the activity essentially supports many livelihoods as far as basic needs such as food, health income are concerned. Some of the species harvested are Nile perch (*Lates Niloticus*), Tilapia (*Oreochromis niloticus*), *Bagrus* (Semutundu), *Mormyrus* (Kasulu), and *Barbus* (Kisinja). Other economic activities include; charcoal burning, poultry farming, bars/restaurants and grocery shops. Livestock farming (cows, goats and sheep) is also practiced.

Beach Management Units (BMUs) around landing sites are not yet fully established.
On average the fishers' earn of between Ush 10,000-30,000, an equivalent of US $ 5.5-16.2 per week per fisher. However, majorities of them do not save. Only 9.5% had bank accounts in various locations, which indicates that they attach little value to their future income sources.

12.4 Fishing assets owned

Most of the fishers (89%) owned fishing assets while a few rented. Amongst the assets owned include; boats, oars, hook and gillnets.

11.3.4. Faecal coliforms contamination

The micro-organisms of medical importance were predominantly *Salmonella* and *Shigellosis*. Contamination was higher at the shallow human and water contact points than in the deeper water (Table 11.3). All sites were far above the acceptable limit of 5 colonies per 100 mls of water. Ten colonies and above are indicative of urgent need for health interventions to reduce the threat of disease. Contamination at Kalange was exceptionally high, although that recorded at Namasagali was also of high risk of contamination. Mass health education, home improvement campaigns and mass chemotherapy should be undertaken at the sites to mitigate the effects of disease transmission.

Table 11.3. Feacal coliforms colonies at the inshore and deep points of the transects on Upper Victoria Nile

Transect	Kalange		Kikubamutwe		Kirindi		Namasagali	
Station	Inshore	Deep	Inshore	Deep	Inshore	Deep	Inshore	Deep
No of colonies/100 ml of water	200	40	50	10	60	20	80	20

11.3.5. *Simulium* (Blackfly) larvae survey

Medically important species of *Simulium* flies mostly live in sheltered areas of the river/stream in fast moving waters. Vegetation collected showed no signs of medically important *Simulium* larvae. A total of 55 crabs which were collected did not have any *Simulum* larvae. However, invertebrate survey carried out during this study found some *Simulium* larvae (21 ind. m^{-2}) under plant roots at the eastern and western banks of the Kalenge-Naminya transect.

11.4. Discussion

Results from this survey, the first one of its kind show that the sanitation environment of the riparian communities along the Upper Victoria Nile is poor as indicated by faecal coliform load of over ten colonies per 100 ml of water at all sites. The acceptable limit of coliform load for good sanitation is 5 colonies per 100 mls of water (Barrel *et al.*, 2000). Ten colonies and above are indicative of urgent need for health interventions to reduce the threat of disease. Risk and prevalence of schistosomiasis were noted especially for people predisposed to water by fishing and bathing/swimming activities. River blindness seemed not to be a threat at present along the Upper Victoria Nile.

Therefore, there is a need to sensitize the communities about health hazards through mass health education, home improvement campaigns and mass chemotherapy at the sites to mitigate the effects of disease transmission. The origin of high levels of faecal coliforms (*Salmonella*) contamination should be further monitored.

Voshell, J.R., Jr. 2002. *A Guide to Common Freshwater Invertebrates of North America*. The McDonald & Woodward Publishing Company, Blacksburg, Virginia.

ANNEX A

A scoop-net on River Nile. This gear is used for fishing the small pelagic cyprinid Mukene (*Rastrineobola argentea*).

Washing in the Nile River. One of the ways communities along the river get infected by water-borne diseases especially bilharzias a common disease on the Nile.

Sun-drying the catch. Mukene caught from Kikubamutwe were very small immature fishes. The BIC pen lid shown is 57 mm long.